

ORIGINAL

AO 440 (Rev. 10/93) Summons in a Civil Action

UNITED STATES DISTRICT COURT  
NORTHERN DISTRICT OF CALIFORNIA

DYNAMIC MICRO SYSTEMS SEMICONDUCTOR  
EQUIPMENT GmbH, a German Corporation.

E-filing

SUMMONS IN A CIVIL CASE

v.

CASE NUMBER: **C 04 2881**

SEMITOOL, INC., a Montana Corporation

JL

TO: *See Above Dependents*

**YOU ARE HEREBY SUMMONED** and required to serve upon PLAINTIFF'S ATTORNEY

Samuel B. Shepherd, Esq., SBN 163564  
Quinn Emanuel Urquhart Oliver & Hedges, LLP  
555 Twin Dolphin Drive, Suite 560  
Redwood Shores, CA 94065  
650-801-5000  
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an answer to the complaint which is herewith served upon you, within 20 days after service of this summons upon you, exclusive of the day of service. If you fail to do so, judgement by default will be taken against you for the relief demanded in the complaint. You must also file your answer with the Clerk of this Court within a reasonable period of time after service.

**RICHARD W. WIEKING**

**JUL 16 2004**

CLERK

DATE

(BY) DEPUTY CLERK

**ANNA SPRINKLE**

NDCAO440

COPY

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UNITED STATES DISTRICT COURT  
NORTHERN DISTRICT OF CALIFORNIA

SAN FRANCISCO DIVISION

CASE NO.

DYNAMIC MICRO SYSTEMS  
SEMICONDUCTOR EQUIPMENT GmbH,  
a German corporation,

**COMPLAINT FOR DECLARATORY  
RELIEF OF PATENT  
NONINFRINGEMENT**

Plaintiff,

**CERTIFICATE OF INTERESTED  
ENTITIES OR PERSONS**

v.

SEMITOOL, INC., a Montana corporation,

Defendant.

NOW COMES the Plaintiff, Dynamic Micro Systems Semiconductor Equipment GmbH,  
by and through its attorneys, and complains against the Defendant, Semitool, Inc., as follows:

1. This is an action for Declaratory Judgment pursuant to 28 U.S.C. §§ 2201 and  
2202, for the purpose of determining an actual controversy between the parties as hereinafter  
more fully appears.

**PARTIES**

2. Plaintiff, Dynamic Micro Systems Semiconductor Equipment GmbH ("DMS"), is a German corporation, with a place of business in Phoenix, Arizona.

3. Defendant, Semitool, Inc. ("Semitool"), is a Montana corporation, with a place of business in Kalispell, Montana.

**JURISDICTIONAL ALLEGATION**

4. This Court has jurisdiction over this matter pursuant to 28 U.S.C. §§ 1331 and 1338 since this action arises under Title 35 of the United States Code.

5. Venue is proper in this District pursuant to 28 U.S.C. § 1391(b)(1) and (c) inasmuch as Semitool is deemed to reside in this district since it is subject to personal jurisdiction here.

**FACTUAL BACKGROUND**

6. DMS has been and is currently engaged in the manufacture and sale of centrifugal force cleaning machines that clean carriers that are used in the manufacture of semiconductors, among other things.

7. On April 9, 2001, Semitool sued DMS in the United States District Court for the Northern District of California asserting that DMS's Model 300 and Model 310 cleaning machines infringed United States Patent Nos. 5,562,113 ("the '113 patent"), 5,738,128 ("the '128 patent"), and 5,972,127 ("the '127 patent").

8. The '113 patent and the '127 patent are attached to this Declaratory Judgment Complaint as Exhibits A and B, respectively.

9. The action was titled "Semitool, Inc. v. Dynamic Micro Systems Semiconductor Equipment GmbH," given case number C01-1391 WHA, and assigned to the Honorable William Alsup.

10. On October 21, 2002, Judge Alsup entered a Stipulation and Order Granting Permanent Injunction. *See* Exhibit C.

11. Per the Stipulation and Order, DMS agreed to immediately stop making, using, selling, or offering for sale in the United States its "Model 300 or Model 310, as presently

1 configured, or any other device that is no more than colorably different from the present  
2 configurations of the Model 300 or Model 310.” *Id.* at 3, 6.

3 12. DMS has abided by the Stipulation and Order at all times.

4 13. In 2003, DMS began offering for sale in the United States a new centrifugal force  
5 cleaning machine, its M204 Tornado.

6 14. On May 25, 2004, Semitool wrote to DMS expressing its concern that DMS was  
7 continuing to sell its Model 300 in the United States, in violation of the Stipulation and Order.  
8 *See* Exhibit D.

9 15. On May 26, 2004, DMS responded that it had discontinued selling its Model 300  
10 in the United States per the Stipulation and Order. *See* Exhibit E. DMS also advised Semitool,  
11 however, that it had begun marketing a new centrifugal force cleaning machine in the United  
12 States. *Id.* at 2.

13 16. On May 26, 2004, Semitool wrote back asking DMS to identify its new machine  
14 by trade name, “and generally describe how its operation differs from the Model 300.” *See*  
15 Exhibit F.

16 17. On June 4, 2004, DMS replied, noting that while it was under no obligation to  
17 provide this information, “DMS has marketed the cleaning processor in question ... under the  
18 trade name ‘204 Tornado.’” *See* Exhibit G.

19 18. On June 4, 2004, Semitool wrote back, claiming that the Stipulation and Order  
20 required DMS to provide more information to Semitool. *See* Exhibit H.

21 19. On June 7, 2004, to demonstrate its good faith, DMS provided Semitool with a  
22 copy of a confidential document, its International Patent Application, that described in detail  
23 some of the new concepts behind its M204 Tornado. *See* Exhibit I.

24 20. On June 29, 2004, Semitool wrote to DMS asserting that DMS’s M204 Tornado  
25 “is merely a slight redesign of DMS’s Model 300,” and charged that it at least infringed claims  
26 39 and 56 of the ‘113 patent, and claims 20, 21, 22, 25, and 26 of the ‘127 patent. *See* Exhibit J.

27  
28

21. As a result of the above-described events, a case of actual controversy within this Court's declaratory judgment jurisdiction exists between DMS and Semitool with respect to the '113 and the '127 patents.

**COUNT I – NONINFRINGEMENT OF THE '113 PATENT**

22. DMS incorporates by reference all of the averments contained in Paragraphs 1 through 21 as though fully rewritten herein.

23. DMS's M204 Tornado does not infringe any claim of Semitool's '113 patent.

**COUNT II – NONINFRINGEMENT OF THE '127 PATENT**

24. DMS incorporates by reference all of the averments contained in Paragraphs 1 through 23 as though fully rewritten herein.

25. DMS's M204 Tornado does not infringe any claim of Semitool's '127 patent.

**PRAYER FOR RELIEF**

**WHEREFORE** Plaintiff DMS submits that it is entitled to judgment that:

A. DMS's M204 Tornado does not infringe Semitool's '113 and '127 patents;

B. Semitool, its officers, agents, employees, attorneys, and all persons in active concert or participation with them, are forever enjoined from asserting such patents against DMS's M204 Tornado;

C. DMS shall recover from Semitool its costs, including attorneys' fees, pursuant to 35 U.S.C. §285; and

D. DMS shall recover such other relief as the Court may deem just and equitable.

Dated: July 16, 2004

QUINN EMANUEL URQUHART OLIVER &  
HEDGES, LLP

  
Samuel B. Shepherd  
Attorney for Plaintiff  
DYNAMIC MICRO SYSTEMS  
SEMICONDUCTOR EQUIPMENT GmbH

**CERTIFICATE OF INTERESTED ENTITIES OR PERSONS**

Pursuant to Civil L.R. 3-16, the undersigned certifies that as of this date, other than the named parties, there is no such interest to report.

Dated: July \_\_, 2004

QUINN EMANUEL URQUHART OLIVER &  
HEDGES, LLP

\_\_\_\_\_  
Samuel B. Shepherd  
Attorney for Plaintiff  
DYNAMIC MICRO SYSTEMS  
SEMICONDUCTOR EQUIPMENT GmbH





[11] Patent Number: 5,562,113

[45] **Date of Patent:** \* Oct. 8, 1996

- |       |   |           |         |                       |            |
|-------|---|-----------|---------|-----------------------|------------|
| [54]  | <b>CENTRIFUGAL WAFER CARRIER<br/>CLEANING APPARATUS</b>   | 3,727,620 | 4/1973  | Orr .....             | 134/95.2   |
|       |   | 3,769,992 | 11/1973 | Wallestad .           |            |
|       |   | 3,853,622 | 12/1974 | Ruten .               |            |
| [75]  | Inventors: <b>Raymon F. Thompson</b> , Lakeside;<br><b>Aleksander Owczarz</b> , Kalispell, both<br>of Mont. | 3,990,462 | 11/1976 | Elftmann et al. .     |            |
|       |   | 4,077,416 | 3/1978  | Johnson, Jr. et al. . |            |
|       |   | 4,132,567 | 1/1979  | Blackwood .....       | 134/153 X  |
|       |   | 4,197,000 | 4/1980  | Blackwood .....       | 134/95.2 X |
| [73]  | Assignee: <b>Semitool, Inc.</b> , Kalispell, Mont.  | 4,208,760 | 6/1980  | Dexter et al. .       |            |
|       |   | 4,370,992 | 2/1983  | Choudhury et al. .    |            |
| [ * ] | Notice: The term of this patent shall not extend<br>beyond the expiration date of Pat. No.<br>5,224,503.    | 4,456,022 | 6/1984  | Roberts .             |            |
|       |   | 4,694,527 | 9/1987  | Yoshizawa .           |            |
|       |   | 4,745,422 | 5/1988  | Matsuoka et al. .     |            |
|       |   | 4,750,505 | 6/1988  | Inuta et al. .        |            |
|       |   | 4,788,994 | 12/1988 | Shinbara .            |            |
| [21]  | Appl. No.: <b>360,724</b>   |           |         |                       |            |

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 § 371 Date: **Feb. 21, 1995** 3815018 12/1988 Germany .  
 12576 1/1977 Japan ..... 134/902  
 § 102(e) Date: **Feb. 21, 1995** 1111338 4/1989 Japan .

[87] PCT Pub. No.: **WO93/26035** OTHER PUBLICATIONS  
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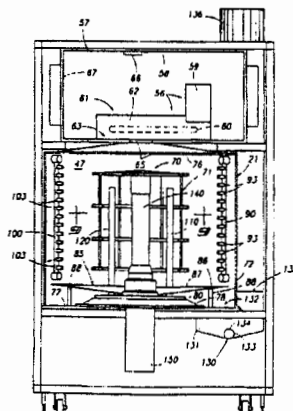
Takeshi Hattori et al.; *Microcontamination*, vol. 9, No. 12; Introducing a New PFA Wafer-Carrier Cleaning Technology; Dec. 1991; pp. 17-21.

*Primary Examiner*—Philip R. Coe  
*Attorney, Agent, or Firm*—Wells, St. John, Roberts, Gregory  
& Matkin, P.S.

## ABSTRACT

**Apparatus (20)** for cleaning carriers used to hold semiconductor wafers, substrates, data disks, flat panel displays and similar containers used in applications highly sensitive to contamination. The apparatus has a processing bowl (21) with entrance and exit ports (34, 36) through which carriers are installed and removed from processing chamber (21). Rotor (70) rotates within the processing chamber. Rotor (70) includes a rotor cage (71) which mounts detachable wafer carrier supports (214). Filtered, heated air is passed through the process chamber for drying. Cleaning liquid and additional drying gas can be supplied through manifolds (120, 110) positioned inside and outside rotor cage (71).

**57 Claims, 13 Drawing Sheets**





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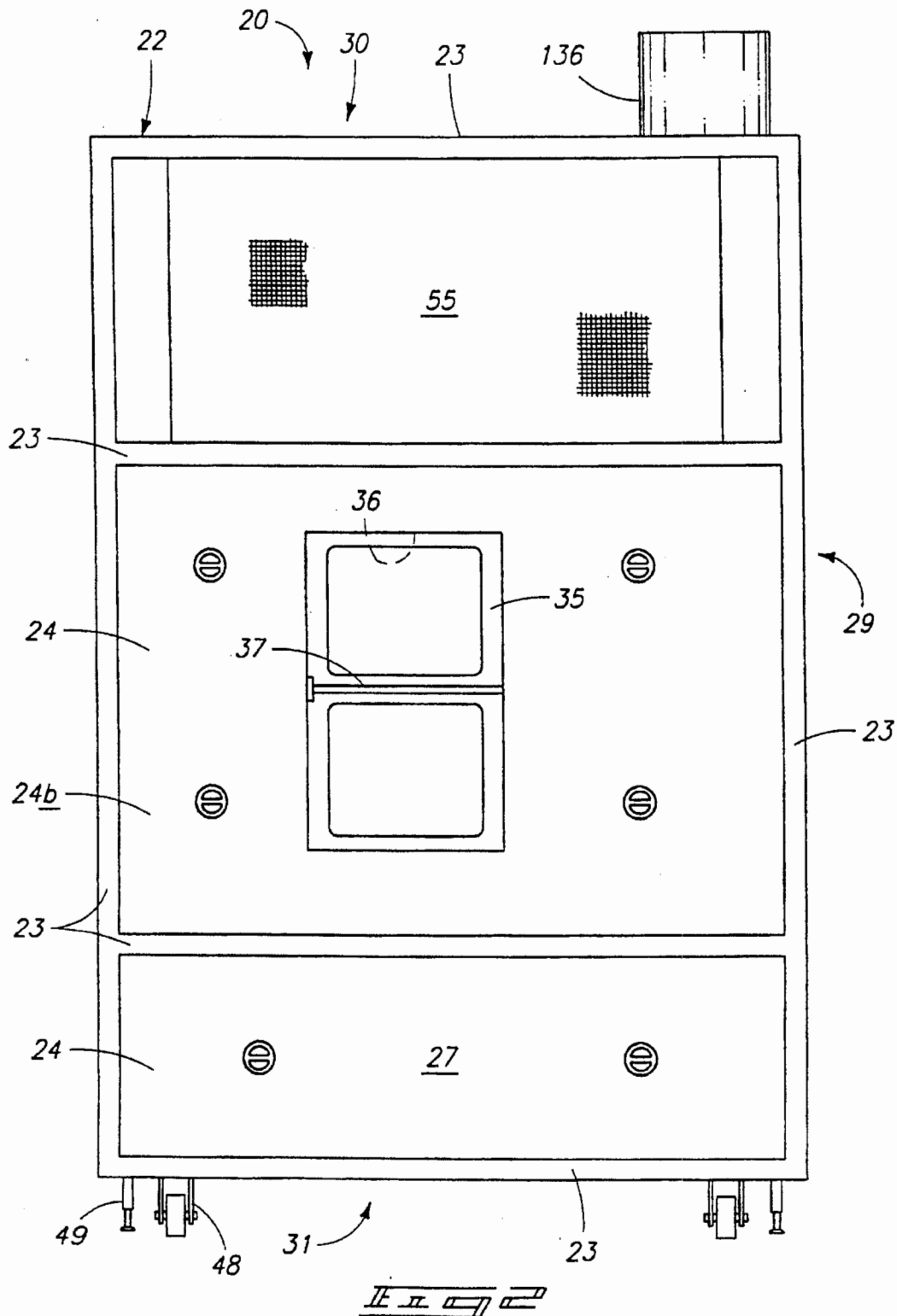


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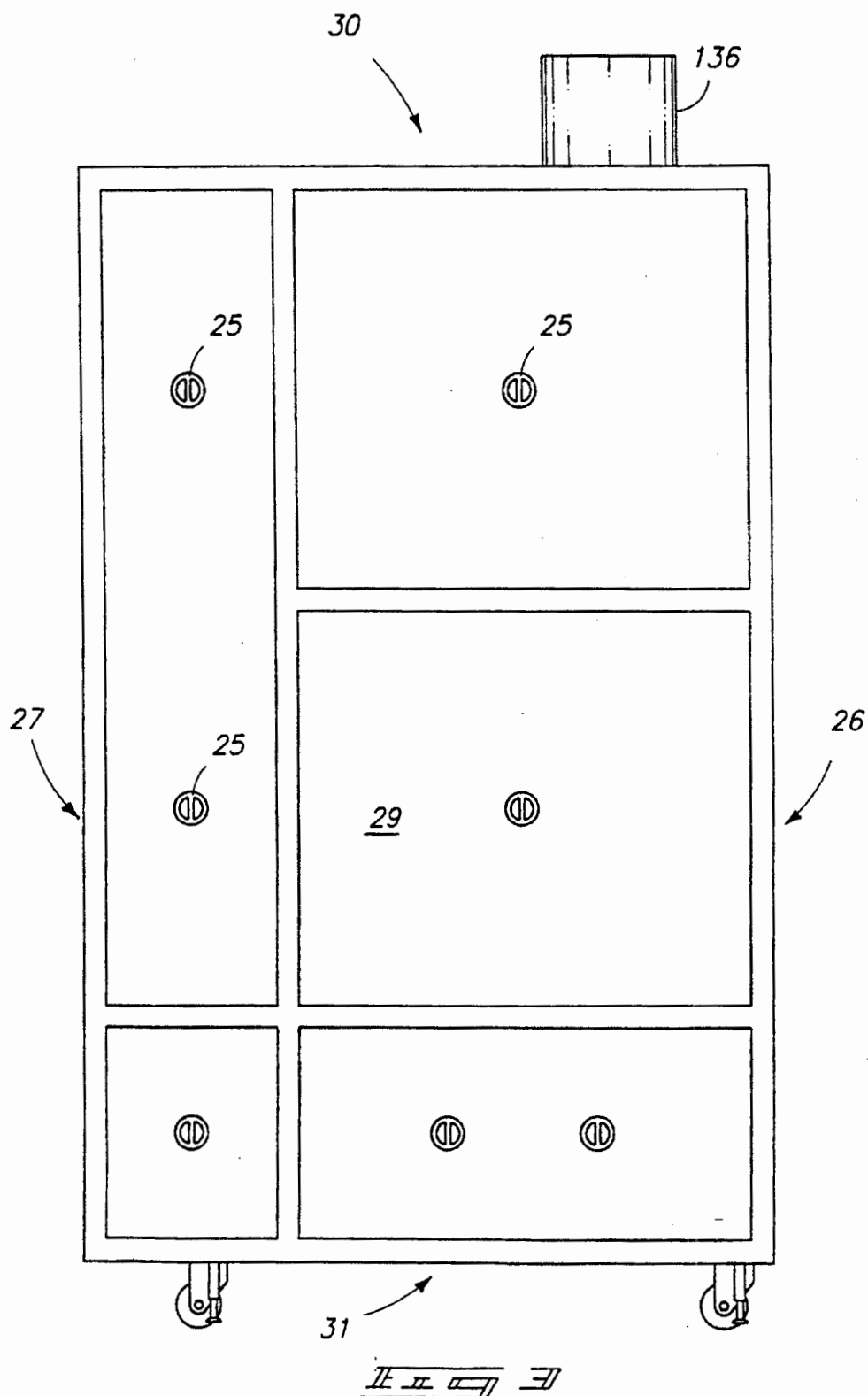


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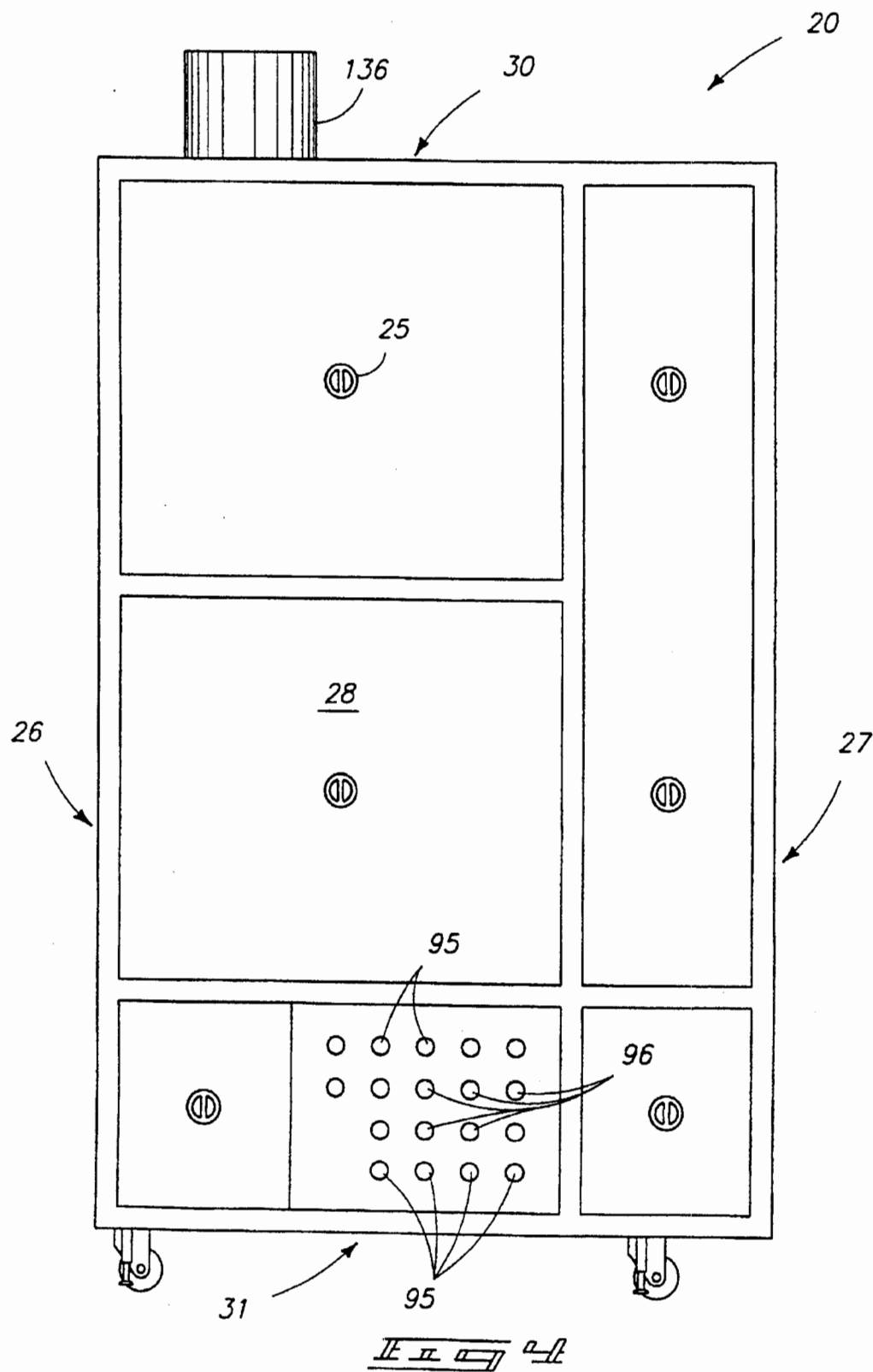


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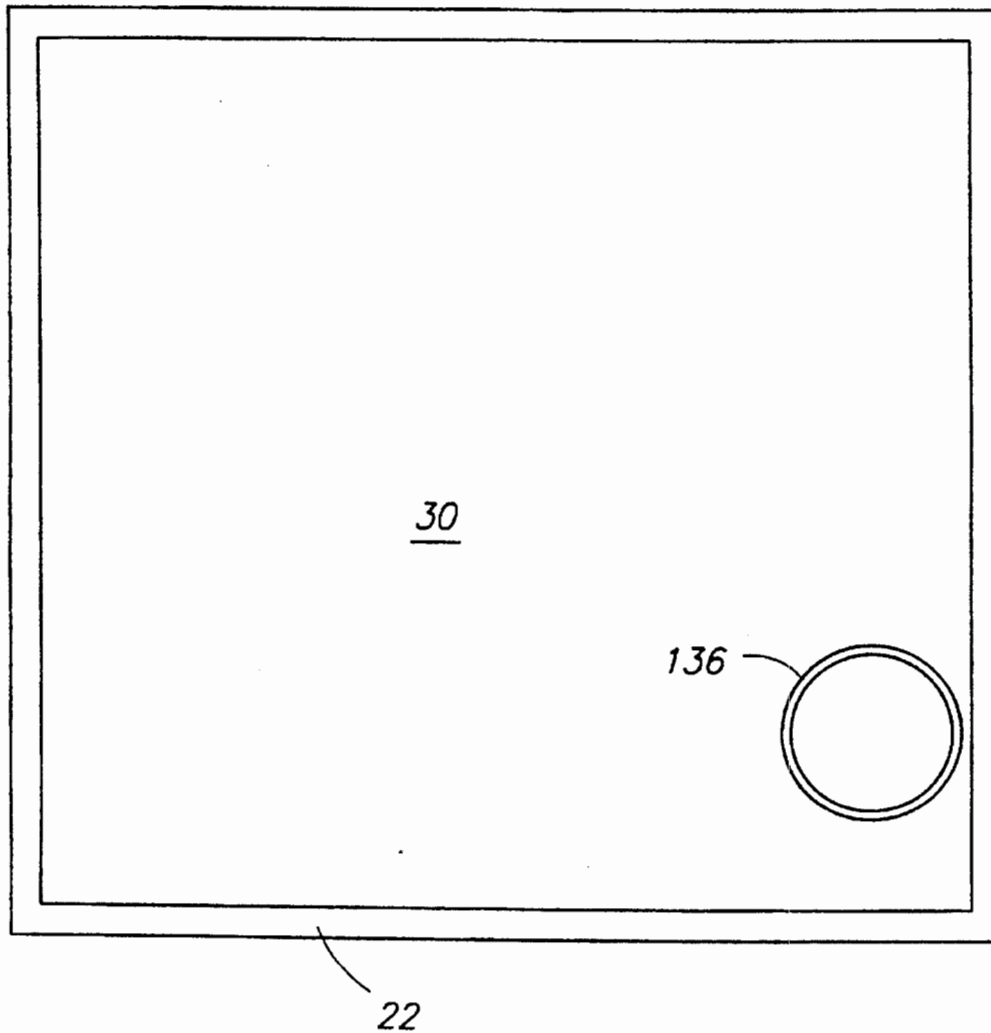


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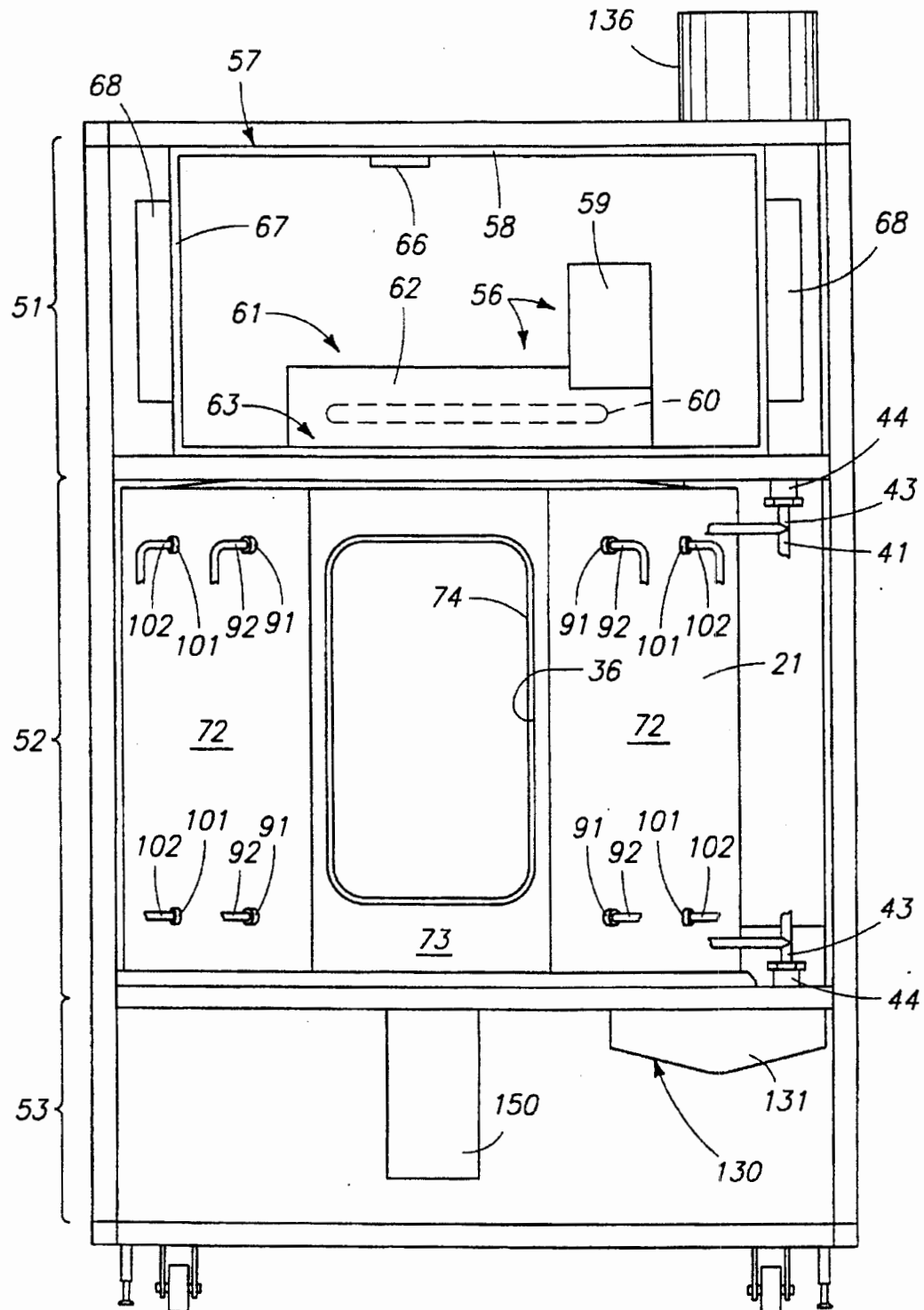
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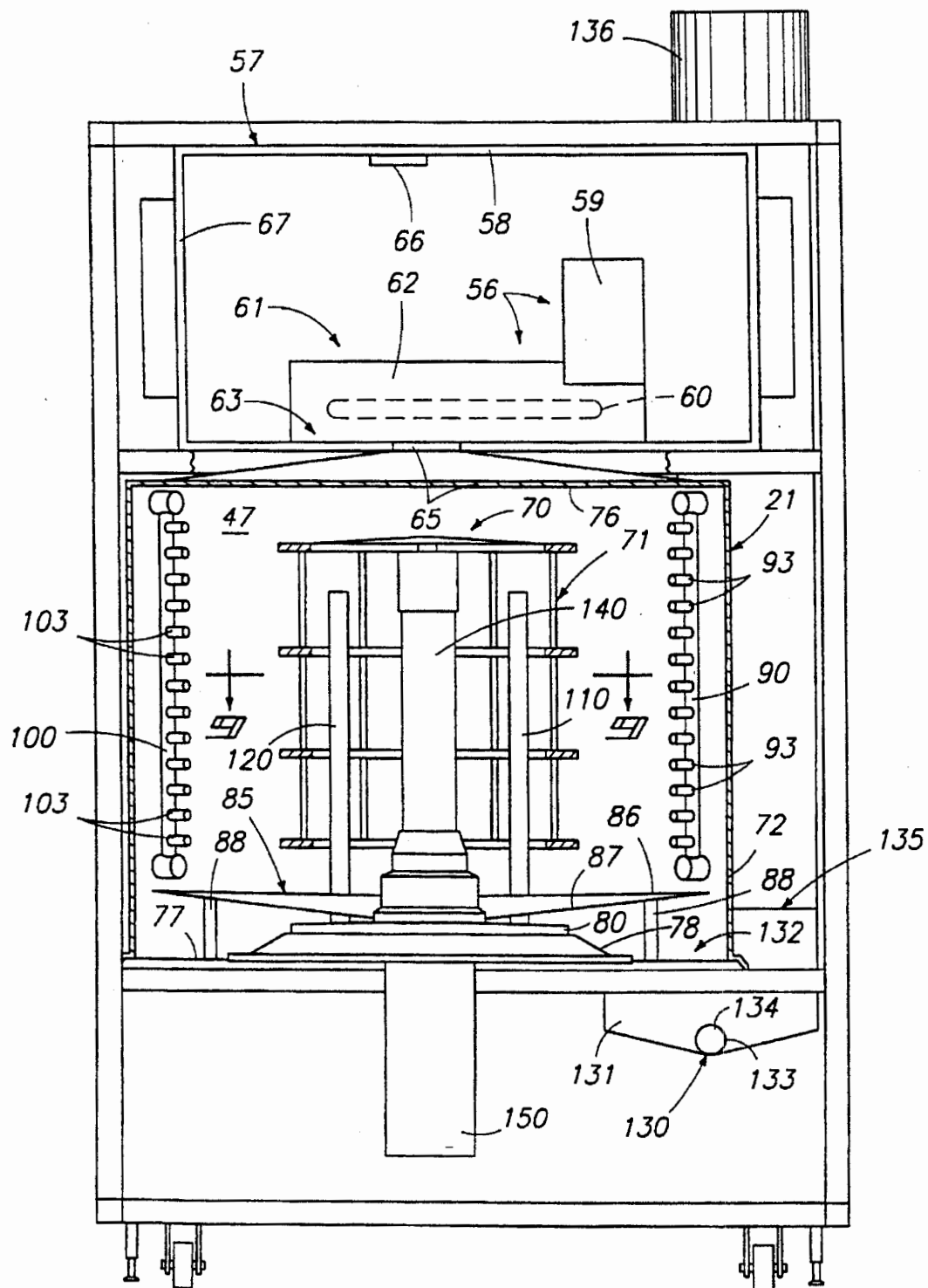


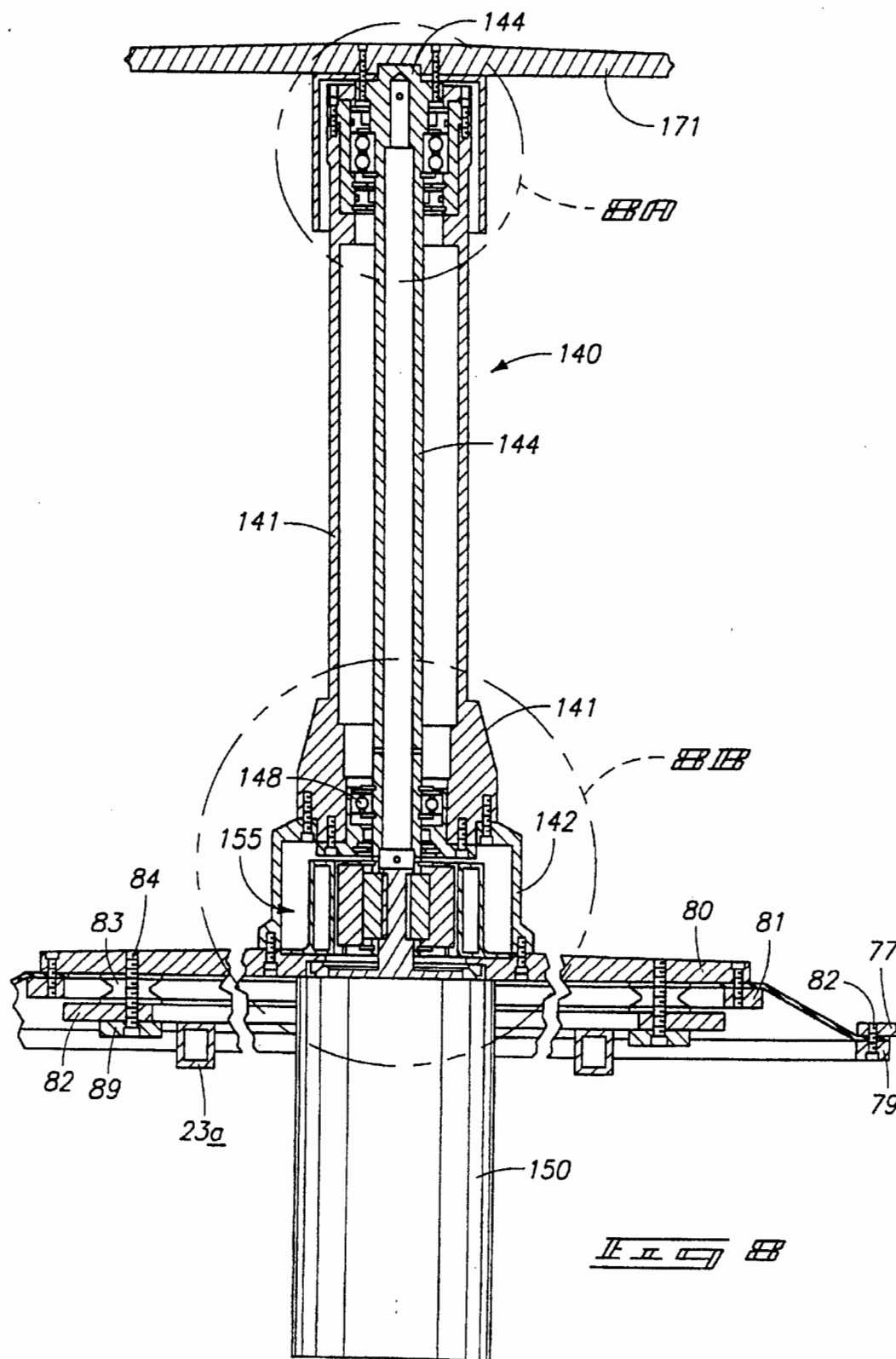
FIG. 7

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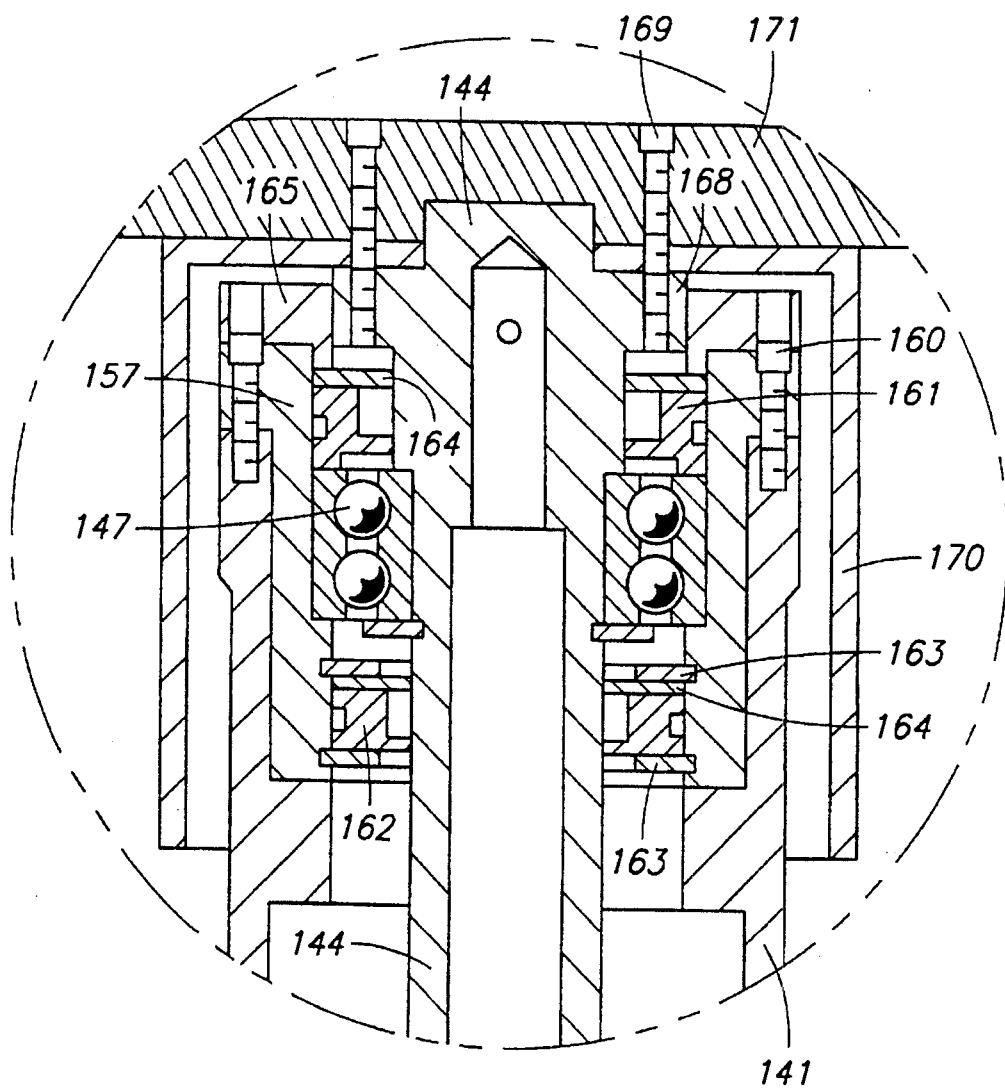


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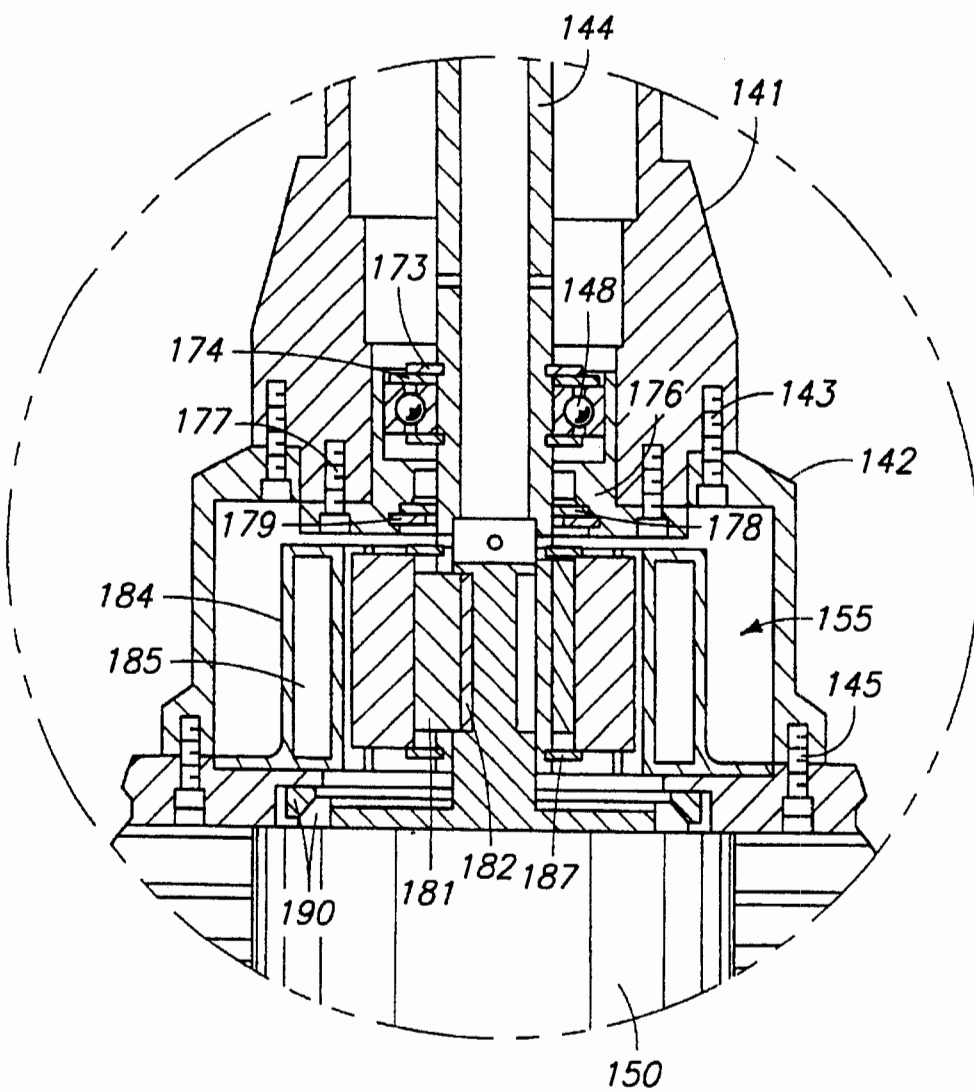
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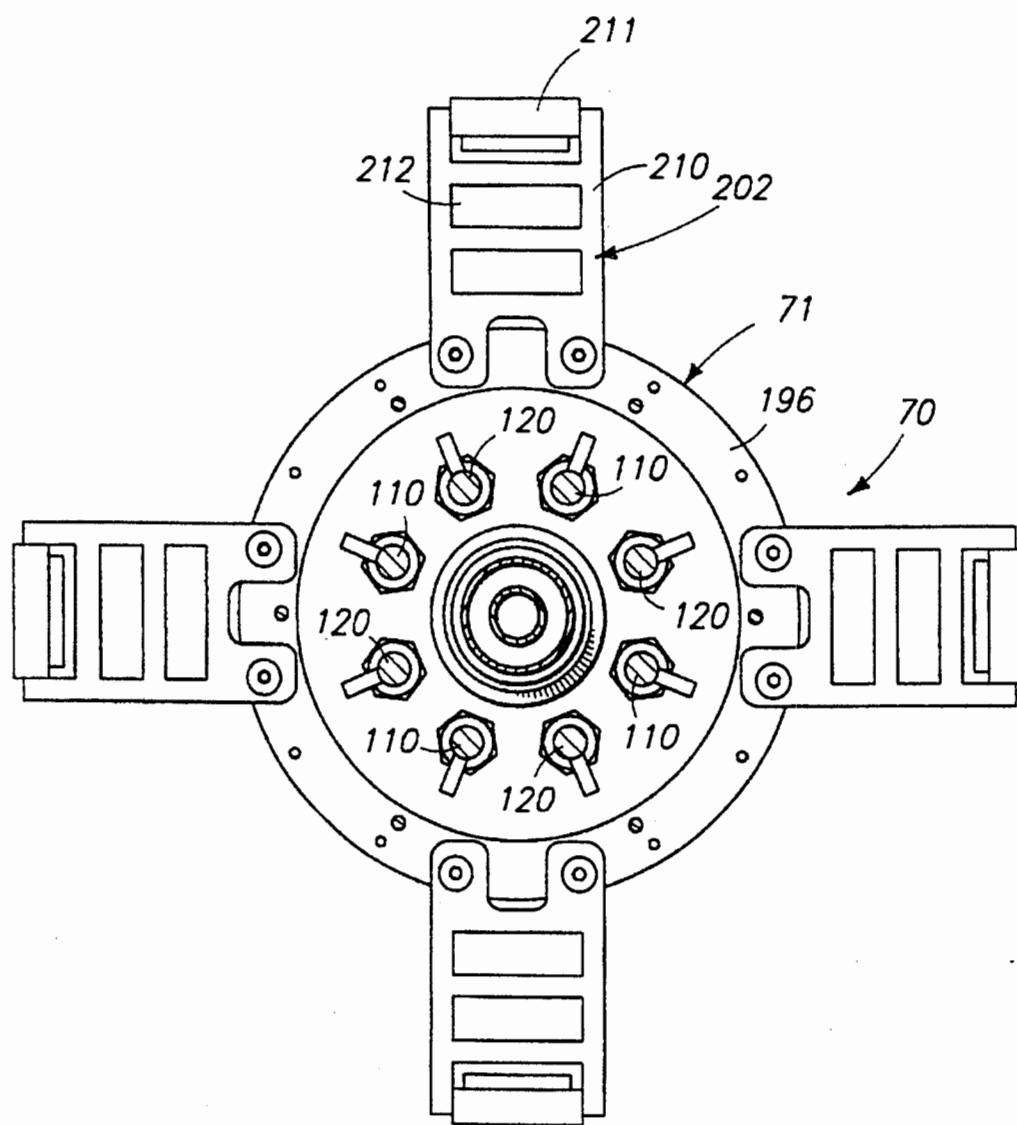


FIG. 9

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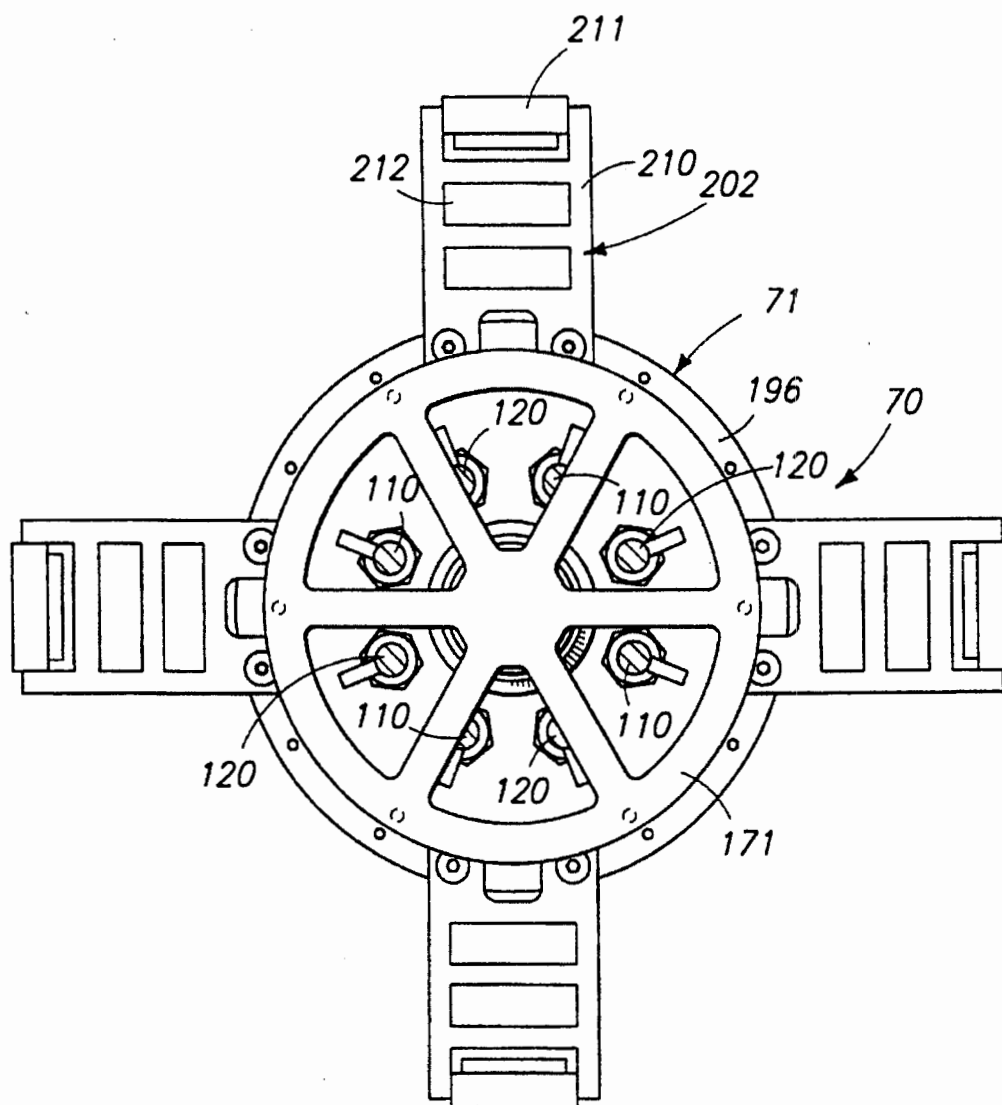


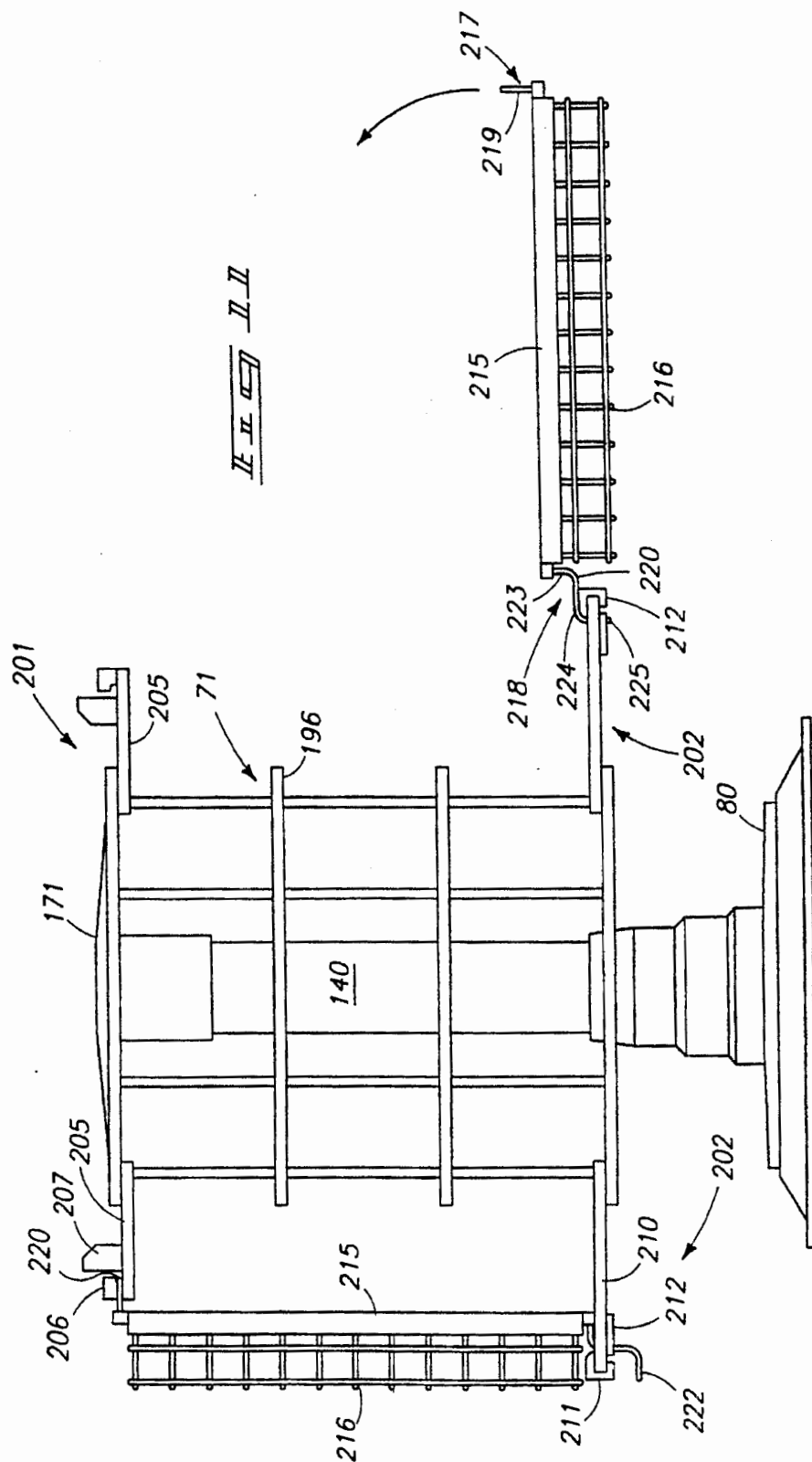
FIG. 10

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## CENTRIFUGAL WAFER CARRIER CLEANING APPARATUS

This is a continuation of U.S. patent application Ser. No. 07/901,614, filed Jun. 15, 1992, now U.S. Pat. No. 5,224, 503.

### TECHNICAL FIELD

The technical field of this invention is cleaning apparatus for rinsing and drying carriers used to hold and process semiconductor wafers, substrates, flat panel displays and similar articles requiring extremely low contamination levels.

### BACKGROUND ART

The processing of semiconductor wafers and substrates is very sensitive to problems of contamination. This is also true with photomasks, flat panel displays, data disks, and other articles relating to the semiconductor industry. These articles require extremely low contamination levels. Even minute contaminants can cause defects to occur in the processing of these low-contamination wafer articles. Accordingly, it is necessary to maintain a high level of cleanliness during all or nearly all stages of production.

Semiconductor wafers, substrates, photomasks, flat panel displays and other similar low-contamination wafer products are also typically processed in batches. Batch handling may occur throughout the entire production process, or for one or more processing steps or related handling operations. Batch processing of this type almost always utilizes some type of carrier or carriers to hold the thin wafer-like materials being processed.

In the batch processing of semiconductor substrates and wafers, a wafer carrier is used to hold a group of these articles. The wafer carriers can be of various designs and are more specifically referred to as a wafer boat. In many applications the wafer boat is made of a suitable polymeric material, e.g. polypropylene or TEFLON® fluoropolymer. The sides and sometimes the bottom of the wafer boat have receiving slots formed to receive and positionally restrain the wafers in a spaced array with the faces of the wafers adjacent one another. Typically, the central axes of the wafers are aligned. The wafers are slid into the boat, such as from the side or above and removed by sliding them outwardly. The receiving slots in the wafer boat are shallow so that the wafer is engaged only at the peripheral edges and along a thin marginal band extending inwardly from the periphery.

Wafer carriers can also be provided in the form of a protective case or box in which the wafers are held and enclosed against contamination during travel within the processing facility. Wafer carriers of this type are frequently designed to hold a wafer boat having a complementary design. The complementary relationship of the protective wafer carrier box and the wafer carrier boat allow the boat and supported wafers to be fully enclosed and positionally restrained in all directions during transport.

The manufacture of wafer carriers also includes their cleaning. Cleaning of wafer carrying boxes and wafer carrying boats is difficult because they typically have features which include slots, grooves or apertures which are difficult to fully clean. This is greatly exacerbated by the extremely low contamination levels which can be accepted for articles used directly or indirectly in processing of the wafer articles. Dust, metal particles, oils and other organic chemicals may

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be present on the surfaces of the molds or other production tools used to make wafer carriers. Fully cleaning the wafer carriers to the required extremely low contamination levels is also difficult. Cleaning the wafer carriers for use in semiconductor processing is a task which in some cases is almost as difficult as mechanically forming the article.

The cleaning of wafer carriers has until this invention remained a difficult and relatively costly procedure. The current invention has several advantages and benefits which are explained or otherwise indicated herein.

### BRIEF DESCRIPTION OF THE DRAWINGS

One or more preferred forms of the invention are described herein with reference to the accompanying drawings. The drawings are briefly described below.

FIG. 1 is a front elevational view of a preferred embodiment of cleaning apparatus according to the current invention.

FIG. 2 is a rear elevation view of the apparatus shown in FIG. 1.

FIG. 3 is a left side elevational view of the apparatus shown in FIG. 1.

FIG. 4 is a right side elevational view of the apparatus shown in FIG. 1.

FIG. 5 is a top view of the apparatus shown in FIG. 1.

FIG. 6 is a rear elevational view of the apparatus shown in FIG. 1 with portions removed for purposes of illustration.

FIG. 7 is an additional rear elevational view of the apparatus shown in FIG. 1 with further portions removed for purposes of illustration.

FIG. 8 is a longitudinal sectional view of selected portions of the apparatus of FIG. 1 showing the rotor and drive construction.

FIG. 8A is a longitudinal sectional view showing a portion of FIG. 8 in greater detail.

FIG. 8B is a longitudinal sectional view showing a portion of FIG. 8 in greater detail.

FIG. 9 is a cross sectional view taken along line 9—9 of FIG. 7.

FIG. 10 is a top view of the rotor shown in isolation.

FIG. 11 is a side view illustrating a preferred wafer carrier support construction used in the apparatus of FIG. 1 shown in isolation with the rotor assembly.

FIG. 12 is a detail top view showing in isolation a preferred door construction used in the apparatus of FIG. 1.

FIG. 13 is a detail front view showing in isolation the preferred door construction of FIG. 12.

### BEST MODES FOR CARRYING OUT THE INVENTION AND DISCLOSURE OF INVENTION

FIG. 1 shows a preferred centrifugal wafer carrier cleaning apparatus 20 according to this invention. Apparatus 20 includes a processing bowl or vessel 21 and a frame 22. Frame 22 has a number of frame members 23 which run both vertically and horizontally and are joined together to form an assembly which acts as the structural framework of apparatus 20. External finish panels 24 are detachably mounted between the frame members using suitable fasteners. As shown the finish panels are adapted for convenient detachment and reinstallation using a panel mounting system. The panel mounting system advantageously includes panel latch

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assemblies which utilize latch activators 25 to controllably latch and unlatch the finish panels. The latch activators 25 are connected mechanically to latch pins (not shown) which engage with the frame members 23 at suitable locations. The finish panels can be temporarily removed to allow maintenance upon internal components. The assembly of frame 22 and finish panels 24 in combination form the exterior or outer surfaces of cleaning apparatus 20.

Wafer carrier cleaning apparatus 20 includes a front side 26, rear side 27, right side 28, left side 29, top side 30, and bottom side 31. Front side 26 has an associated entrance closure or first door 33 which is controllable to open and close a first opening or entrance port 34 formed in the sidewall of processing vessel or bowl 21. Rear side 27 has an associated exit closure or second door 35 which is controllable to open and close a second opening or exit port 35 which is also formed in the sidewall of processing bowl 21. FIGS. 1 and 2 show doors 33 and 35 in fully closed positions wherein the entrance and exit ports 34 and 36 are closed and substantially sealed shut to prevent fluid leakage.

FIG. 11 shows that doors 33 and 35 are preferably supported upon a door support structure having upper and lower guides 38 and 39. Guides 38 and 39 are advantageously connected to inner and outer vertical connection bars 41 and 40. The inner connection bar 41 has journal extensions 43 which are supported in bearing blocks 44 (see FIG. 6) mounted upon frame 22. The door support structures for doors 33 and 35 are mounted behind the adjacent central finishing panels 24a and 24b. The corners of doors 33 and 35 are provided with rollers 42 which roll upon the guides 38 and 39. Doors 33 and 35 are preferably operated relative to the door support structures by pneumatic rams 37. The door support structures and doors are pivoted inwardly to seal against the peripheral flange of the entrance and exit ports. This is done by controllably pivoting the door support structures using a door pivot actuator 45 which is advantageously a pneumatic ram extending between the outer vertical bar 40 and an adjacent frame member 23 (shown in phantom in FIG. 12).

The door is operated in the following manner. The pivot actuator 45 is maintained in an extended position until the door 33 has been fully extended toward the outer vertical bar 40. The pivot actuator is then operated to retract the door and support assembly formed by the door and door support structure. Conversely, when opening the door the pivot actuator is first extended to move the door and support assembly outwardly from the processing bowl 21. Thereafter the door is rolled upon the guides 38 and 39 and retracted toward the inner vertical bar 41.

The bottom 31 of apparatus 20 is advantageously provided with a set of casters 48 which are connected to the frame 22 near the bottom corners. The bottom corners of apparatus 20 are also preferably fitted with extendible and retractable stabilizers 49. The stabilizers have a fixed upper part 49a which is connected to the frame. A lower extendible part 49b is adjusted relative to the upper part. Apparatus 20 can thus be rolled to a suitable location. Thereafter the stabilizers can be extended to transfer the weight of the apparatus from casters 48 to the stabilizers and provide increased stability.

FIG. 1 shows that the wafer carrier cleaning apparatus 20 includes three sections 51-53; herein termed the upper of first section 51, the middle or second section 52, and the lower or third section 53. The upper or first section 51 includes a primary drying gas treatment system. The primary drying gas treatment system includes a suitable primary

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drying gas filter 55 shown in FIG. 2. Filter 55 is received within the outer portions of the drying gas plenum 57. FIG. 6 shows that the preferred construction of the plenum includes a filter stop 67 which extends about the interior of the plenum adjacent to but spaced inwardly from the filter opening 58. The filter 55 is installed within the plenum and is in part retained by the filter stop 67. Two connection brackets 68 are advantageously included at the sides of filter opening 58 to assist in mounting a finishing panel which also serves to support the outer face of the filter and keep the filter in the installed position.

In a typical installation the exit or rear side 27 of the apparatus is within a clean room or similar low contamination environment. Air can be pulled from the clean room and through the filter 55. Filter 55 is preferably a HEPA type or other suitable filter capable of removing very small particulate matter with great effectiveness. Filter 55 is constructed with a relatively large surface area to minimize pressure drop associated with moving air or other drying gas there-through. This is helpful in eliminating the need for a specific, dedicated drying air fan which would otherwise increase particulate contamination. Contamination could occur to the primary drying gas flow path if a specific, dedicated drying gas fan was included therein. Such a hypothetical construction could also lead to contamination to the interior processing chamber 47 of vessel 21. Primary drying gas passes through the processing chamber to remove moisture therefrom. A hypothetical fan and associated drive motor which is specifically functions to move primary drying air or other drying gas also generates significant amounts of general contamination within or adjacent to the wafer carrier cleaning apparatus. This general contamination outside the processing vessel 21 nonetheless causes particulate matter to enter the processing chamber and prevents the very low contamination levels needed in the processing of semiconductor and other low-contamination wafer products.

FIG. 6 shows that the upper section 51 of the wafer carrier cleaning apparatus also preferably includes a drying gas heater 56. Drying gas heater 56 is mounted within a primary drying gas plenum 57. Plenum 57 serves as a drying gas enclosure and conduit. Air or other drying gas is passed through filter 55. Filter 55 is mounted within a plenum intake opening 58 which is substantially the entire side of the plenum. Filtered air received within the plenum passes about heater 56. Air within the plenum also passes down through a central heater opening 61 which extends through the lower section 62 of the heater. Heater 56 also has an upper section 59 which is provided with a cover that encloses wiring connections and mounts for an array of spaced parallel electrical resistance heating elements 60 mounted within the lower section of the heater and across the central opening 61. Each heating element 60 is preferably provided with a multitude of fins to improve heat transfer to the air or other primary drying gas passed thereover.

Air passes down through the central heater opening 61 and from the plenum through a plenum exhaust opening 63 in the central bottom of the plenum. The plenum exhaust opening is open to a processing bowl top port 65 (FIG. 7). Opening 63 and top port 65 allow communication of filtered, heated drying gas from the plenum into the processing vessel at a position substantially aligned with the central axis of the processing chamber and the rotational and longitudinal axis of rotor 70.

The primary drying gas plenum 57 is also preferably provided with a static electricity suppressor 66. Static suppressor 66 can be selected from suitable types of commercially known units. It preferably has exposed electrodes



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which are charged to desired electrical potentials to help neutralize static electricity generated by movement of drying gas through plenum 57 and over associated surfaces of the plenum and enclosed heater 56. The particular operating parameters used may vary dependent upon environmental and climatic conditions.

FIG. 6 shows that the middle or second section 52 includes the processing vessel or bowl 21. The processing bowl 21 is mounted upon the frame 22 using suitable fasteners (not shown). Processing bowl 21 is roughly cylindrical having semicircular sidewall sections 72. The sidewall of the processing bowl is completed by two substantially flat panels 73 on the opposing front and rear sides. The first or entrance flat sidewall panel includes the first or entrance port 34. The exit or second flat sidewall panel includes the second or exit port 36. Both the entrance and exit ports are preferably built with port flanges 74 which are relatively thicker than the sidewall panels 73 to strengthen the vessel and provide surfaces against which the doors 33 and 35 can seal. FIG. 6 has been simplified by not showing the rotor assembly 70 through the port 74. The details of the rotor and other internals of the processing bowl are described in connection with FIG. 7.

FIG. 7 shows that the processing bowl also has a top wall 76. The top wall is most preferably a relatively low flat frustoconical shape. The top wall has the top port 65 which serves as a primary drying gas supply formed therethrough. Port 65 thus provides an inlet to primary drying gas flowing from the plenum 57 into the processing chamber 47.

The processing bowl also has a bottom wall which is of composite construction. FIG. 8 illustrates specifics of the preferred construction. The first part of the bottom wall is an outer bottom wall piece 77 which is annular and connects to the lower edges of the processing bowl sidewall sections 72 and 73. The central portion of the bottom wall is open to provide a construction which accommodates inherent vibration of the rotating assembly and associated drive which will be described in greater detail hereinafter. This construction utilizes a flexible membrane or diaphragm 78 which is annular and extends inwardly from the inner edge of an annular outer bottom wall piece 77. The outer edge of the annular diaphragm 78 is captured between the outer bottom wall piece 77 and an outer diaphragm retaining ring 79 which is connected thereto using suitable fasteners. The inner edge of diaphragm 78 is raised relative to the outer edge, and is connected to a drive mount base plate 80. A diaphragm inner edge retaining ring 81 is connected by fasteners below the base plate 80 to capture diaphragm 78 therebetween.

The processing chamber 47 is also most preferably provided with a false bottom or bottom baffle 85. The bottom baffle is sized to provide a space between its outer periphery and the inside surfaces of the processing bowl sidewalls. This annular exhaust and drain baffle space allows exhausting gas and draining liquids to flow across and down about the outside of the baffle. Bottom baffle 85 is most preferably constructed using two baffle parts, an upper or first baffle part 86, and a lower or second baffle part 87. The upper baffle part is flat, or more preferably, slightly crowned to drain liquids which fall thereon. The lower baffle part 87 is frustoconical expanding upwardly to connect with and support the peripheral edge of the upper baffle part 86. The bottom baffle assembly 85 is supported upon baffle mounting brackets 88 which extend upwardly from the outer bottom wall 77 to connect with the lower baffle part 87.

The processing vessel 21 is preferably fitted with at least one outer spray manifold 90. Outer spray manifolds 90 are

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connected directly to the sidewalls 72. External spray manifold supply fittings 91 connect with liquid supply conduits 92. As shown, processing chamber is advantageously provided with four (4) outer spray manifolds 90 at spaced approximately equiangular points about the central axis of the processing chamber. The outer spray manifolds are provided with a plurality of liquid spray nozzles 93. Spray nozzles 93 are directed inwardly to spray water, water and detergent, solvents, mixtures thereof, or other cleaning liquids generally inward or directly toward the central axis of the processing chamber.

FIG. 7 shows that the processing vessel 21 is also preferably fitted with at least one outer drying gas manifold 100. Outer drying gas manifolds 100 are similar to outer cleaning liquid spray manifolds 90 in basic construction and mounting to the processing vessel sidewall 72. The outer drying gas manifolds are supplied with a suitable pressurized secondary drying gas through supply fittings 101 mounted in the sidewall 72. The supply fittings 101 (see FIG. 6) are connected to secondary drying gas supply conduits 102. These conduits are supplied with a suitable secondary drying gas, such as clean dry air or nitrogen. The drying gas manifolds have gas nozzles or jets 103. Jets 103 are inwardly directed to provide streams of secondary drying gas which impinge upon the wafer carriers being dried. As shown, there are four (4) outer secondary drying gas manifolds 100 which are spaced approximately equiangularly about the processing chamber. The gas manifolds and spray manifolds are advantageously arranged in alternating sequence about the diameter of the circular outer manifold array formed by manifolds 90 and 100.

FIGS. 7 and 9 also indicate that processing chamber 47 is preferably provided with a number of inner liquid spray manifolds 110 and inner secondary drying gas manifolds 120. The function of manifolds 110 is to spray cleaning and rinsing liquid(s) at wafer carriers mounted upon the rotor 70. The inner spray manifolds are mounted in a circular array at approximately equiangularly spaced positions, as shown in FIG. 9. The inner liquid spray manifolds are mounted to the bottom baffle 85 and extend upwardly at radial positions which are within the cage 71 of rotor 70. The wafer carriers being cleaned and dried are mounted upon the rotor cage 71, in a suitable manner, such as indicated below. The inner liquid spray manifolds 110 are provided with a plurality of nozzles 113 mounted upon the manifolds at spaced vertical locations. The nozzles are directed in a generally outward or radial direction toward the rotor cage.

FIG. 9 shows an array of inner secondary drying gas manifolds 120 interpositioned in an alternating pattern with the inner liquid spray manifolds 110. As shown there are four (4) manifolds 120 which are approximately equiangularly arranged about the central axis of the processing chamber and the rotational axis of rotor 70. Manifolds 120 have a plurality of vertically spaced nozzles or jets 123 arranged along the upstanding manifolds. The jets direct diverging streams of secondary drying gas in a generally outward direction toward the rotor cage 71 and against wafer carriers supported thereon. The drying gas is used to blow and evaporate any rinsing or washing liquids from the surfaces of the rotor and supported wafer carriers being cleaned.

Liquid supplied to spray manifolds 90 and 110 and secondary drying gas supplied to manifolds 100 and 120 are preferably controlled by an automatic controller (not shown) which operates electrical solenoid valves (not shown). The electrical solenoid valves control the flow of compressed air or other pneumatic control gas or other suitable fluid. The

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control gas is controllably delivered to pneumatically controlled solenoid valves which directly control the flow of cleaning liquids and drying gas to the manifolds 90 and 100. Manual cleaning fluid supply valves (not shown) and manual secondary drying gas valves (not shown) are also connected in parallel with the pneumatically controlled valves to allow manual operation if desired.

Pressure gauges 95 (see FIG. 4) are advantageously used to provide an indication of the pressures to the spray and gas manifolds. Associated pressure regulator valves 96 are also included to allow manual regulation of the delivery pressures to the manifolds.

The processing vessel 21 is also provided with a suitable means for draining liquids therefrom. It is further provided with a suitable means for exhausting the drying gases. As shown, wafer carrier cleaning apparatus 20 includes a liquid drain and gas exhaust subsystem 130 which in part combines these functions. The drain and exhaust subsystem 130 includes an outflow box 131. Outflow box 131 is mounted beneath the bottom wall of the processing bowl 57. The outer bottom wall piece 77 has a processing chamber outflow opening or port formed therethrough adjacent to the outflow box. Liquids drain across the bottom wall of the processing bowl and into the outflow box. Gases flow from the processing chamber through the outflow port and into the outflow box 131. The bottom of the outflow box is sloped toward a central trough and a liquid outflow drain opening 134. A liquid drain line or conduit 133 extends from the drain opening 134 and carries liquids draining from the processing chamber to a suitable facilities drain pipe or sewer.

The outflow box 131 also has a gas exhaust port 135 which passes exhausting gases from the outflow box into a suitable gas exhaust conduit. As shown, the gas exhaust conduit is in the form of an upstanding exhaust gas stack 136. Exhaust stack 136 is connected to a suitable facilities exhaust system to remove the gas and contained liquid vapors removed from the processing chamber.

FIG. 7 shows portions of a rotating assembly which includes the rotor 70 with attached rotor cage 71. The rotor is supported in an upright position by a rotor housing 140. Rotor housing 140 is mounted upon base plate 80. Base plate 80 is supported upon frame drive assembly mounting members 23a which extend in a generally front-to-back orientation. Members 23a are a weldment subframe which attaches to the frame 22. This is advantageously accomplished using a drive assembly mounting ring 82 which is bolted to members 23a. Elastic mounting bushings 83 are interpositioned between the base plate and mounting ring 82 to accommodate vibration and shock. Fasteners 84 extend through apertures in fastener caps 89, ring 82, bushings 83 and base plate 80, to secure the base plate to the frame in a manner suitable for dissipating vibration and shock.

A drive motor 150 is mounted beneath the base plate 80 to drive the rotating assembly. Motor 150 extends downwardly into the lower or third section 53 of the wafer carrier cleaning apparatus. Motor 150 is preferably a brushless direct current type electrical motor to prevent particulate contamination associated with contacting electrical brush type motors. The motor is positioned by complementary tapered alignment rings 190.

FIGS. 8, 8a and 8b show in sectional view the rotor, rotor housing, and drive components in greater detail. Rotor 70 includes a rotor shaft 144. Rotor shaft 144 is mounted for rotation within the rotor housing 140. The rotor housing includes an upper or first housing piece 141 and a lower or

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second housing piece 142. The first and second housing pieces are connected by a series of fasteners 143. The rotor housing 140 is connected to the base plate 80 using fasteners 145. The lower second rotor housing also functions as a housing which encloses a brake assembly 155.

FIGS. 8 and 8A show that rotor 70 is mounted for rotation within the upper rotor housing 141 using an upper or first bearing 147 and a lower or second bearing 148. The upper bearing is advantageously a double ball bearing with the outer race of the bearing positioned within an upper rotor bearing mounting sleeve 157. The mounting sleeve 157 is held by fasteners 160 to the upper, distal end of rotor support housing piece 141. Mounting sleeve 157 also holds bearing seals 161 and 162 which seal the bearing area to retain lubricant and prevent migration of particulates generated by the bearings. The first upper rotor bearing seal 161 is captured in position between the outer race of bearing 147 and a retainer ring 165 held by fasteners 160. A shield 166 is also advantageously included to protect seal 161. The second upper rotor bearing seal 162 is held in position using two spring retainer rings 163 on both sides thereof. A suitable shield 164 is also advantageously used.

FIG. 8A also shows that the upper distal end of rotor shaft 144 is preferably provided with a flange 168 having mounting apertures which receive bolts 169. A splash shield or cap 170 is held between the rotor wheel 171 and flange 168 using bolts 169. The shield cap 170 and rotor wheel 171 rotate with shaft 144.

FIGS. 8 and 8B show the lower rotor bearing mounting arrangement and adjacent components. Lower bearing 148 is of a type suitable to support most of the thrust loading caused by the weight of the rotating assembly. Spherical contact self-aligning ball bearings are suitable. The inner rotating race of bearing 148 is held in position upon shaft 144 using spring ring retainers 173. A bearing shield 174 is held in position above bearing 148. The outer race of bearing 148 is held within a lower rotor bearing mounting sleeve 176. Mounting sleeve 176 is connected to the lower or proximate end of rotor housing piece 141 using fasteners 177. Mounting sleeve 176 also mounts a shaft seal 178 using a spring retainer ring 179.

The drive assembly also preferably includes a rotating assembly brake 155. The brake assembly 155 is enclosed within the lower or second rotor housing piece 142. The brake includes a rotating cylindrical brake part 181 which is secured to the rotor shaft 144 and motor output shaft 151 using a key 182 and two opposing spring retainer rings 187. The outer periphery of the rotating cylindrical brake part 181 is contacted by a series of brake contact pads 183. The brake contact pads 183 line the interior face of a cylindrical annulus which serves as a brake actuator 184. Brake actuator 184 is elastically deformable and is inflated by supplying pressurized fluid to the internal expansion chamber 185. When inflated the contact pads are moved inwardly to rub against the outer face of the rotating brake part or drum 181. The rotating assembly can be controllably stopped using the brake system 155. This is important in slowing the rotating assembly and in stopping the rotating assembly in a suitable position for loading and unloading wafer carriers. The rotating assembly is freed to rotate by relieving the pressure within chamber 185.

The rotating assembly also includes a rotor wheel 171 which is mounted to the upper distal end of the upstanding rotor shaft 144. Rotor wheel 171 has a peripheral ring 192 which is connected to a hub 194 using a plurality of spokes 193. The spaces between the spokes are open to facilitate a



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downward flow of primary drying gas from the primary drying gas inlet port 65 into the space within the interior of rotor cage 71.

The rotor wheel supports the rotor cage 71. The rotor cage includes a number of peripheral rings 196. The uppermost peripheral cage ring is advantageously formed by peripheral ring 192 of rotor wheel 171. The cage also includes a number of longitudinal connection bars 197 which extend between the cage rings 196. Reinforcement pieces 198 connect between the rotor wheel and cage to add strength and they also provide addition blade area for moving drying gas as the rotor turns.

The rotary motion of the rotor wheel and rotor cage cause centrifugal action of the drying gas and thereby induces a flow of gas. The flow of drying gas is generally downward into the interior of the rotor cage, and then outward toward the peripheral sidewalls of the processing vessel. The bottom baffle 85 is spaced inwardly from the processing vessel sidewalls leaving an annular flow space thereabout. The centrifugal action of the rotor thus induces an outward flow which proceeds outwardly and downwardly to form a downwash which exits through the annular opening about the bottom baffle. Beneath the bottom baffle the gas flow proceeds across the bottom wall of the processing vessel toward the drain and exhaust box 131. This construction maintains a relatively controlled drying gas flow path which carries liquid vapors from the processing chamber and minimizes turbulence and complex gas flows near the bottom of the chamber which otherwise will occur and derogate the particle counts exhibited by the wafer carriers processed through the cleaning apparatus 20.

FIGS. 9-11 show a preferred construction providing wafer carrier supports 200 which hold wafer carriers in position for cleaning within apparatus 20. As shown there are four (4) wafer carrier supports 200 at spaced, approximately equiangular positions about rotor cage 71. The wafer carrier supports include an upper or first mounting bracket 201 and a lower or second mounting bracket 202. The mounting brackets are secured to the rotor cage rings 196 using suitable fasteners 203. The upper wafer carrier mounting brackets include a main bracket piece 205. Connected thereto are an outer retaining lug 206 and an inner stop piece 207, both of which are advantageously made of nylon or other suitable polymer material. The lower mounting brackets 203 include a main bracket piece 210 which mounts an outer roll bar 211 and an inner rest piece 212.

The wafer carrier supports further include a detachable wafer carrier support basket 214. Wafer carrier support baskets 214 have a perimetric frame 215 and a reticulated basket 216. The baskets have an opening defined by the perimetric frame with the basket extending outwardly to form a wafer carrier storage space therewithin. The wafer carriers are held along the inwardly directed side of the basket 216.

The wafer carrier supports are provided with bracket engaging ends 217 and 218. The first or upper bracket engagement end 217 is adapted to engage with the upper or first mounting bracket 201. The second or lower bracket engagement end 218 is adapted to engage with the lower or second mounting bracket 202. First bracket engagement end 217 has a first end engagement loop 219 which extends approximately perpendicular to the plane defined by the perimetric frame 215. Loop 219 is directed from the basket opening, or upwardly when the basket is laid flat and inwardly when installed upon the rotor. Loop 219 is lifted up and over outer retainer lug 206 and then lowered into the

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position shown at the left in FIG. 11. A retaining groove 220 is formed in the inward face of lug 206 in order to receive and retain the loop in position. Centrifugal action forces the loop into groove 220.

The second or lower bracket engagement end 218 has a loop 222 which extends is curved to form three different sections. The first section 223 is perpendicular to the plane of the basket opening. This first section extends in a direction along the end of the basket and opposite to the direction of the first loop 219. The second section 224 of loop 222 extends parallel to the plane of the basket opening and away from the basket. The first and second sections are joined in a curve which bears upon a curved outer-upper corner of the lower bracket rest or support piece 212. Loop 222 also has a third section which extends and is oriented similar to the first section 223. The second and third sections are joined by a curve which bears upon and rolls over the outer roll bar 211 as the basket is installed. The basket pictured at the right in FIG. 11 shows the starting position. The basket is then pivoted or rolled upwardly and lifted to allow the loop 219 to clear over the lug 206. The basket is then lowered or dropped into the installed position shown at the left in FIG. 11.

The wafer carrier cleaning apparatus is used to perform a wafer carrier cleaning process. The wafer carrier cleaning process begins by loading the wafer carriers into baskets 216. The entrance door 33 is then opened and the loaded baskets are installed upon the rotor through the entrance port 34. This is repeated until all wafer carrier supports have been loaded, preferably with loads having about the same weight. The operation then involves closing the entrance door using the actuating ram 38. The closing also involves sealing and the entrance door to the entrance port 34.

Thereafter the wafer carriers are subjected to a cleaning process which includes rotating the rotor and spraying the wafer carriers with water, solvent, detergent or other washing and cleaning liquid(s) supplied through the inner and outer liquid spray manifolds 110 and 90. The cleaning using liquid spraying and rotating steps is performed for sufficient time to adequately cleanse all surfaces of the wafer carriers being cleaned. The simultaneous spraying and rotating serves to direct the sprays of liquid from differing directions to enhance solubilization of dirt, grease and other contaminants which may be present upon the wafer carriers prior to cleaning.

After treating the wafer carriers with the cleaning liquids, a drying process is advantageously performed. The drying process includes supplying the drying gases to the processing chamber. The primary drying gas is supplied through plenum 57. This primary drying gas is treated by filtering the incoming air or other primary drying gas. Then the primary drying gas is treated by heating it to a desired temperature, such as in the range of 100° F. to 300° F., or higher dependent upon the materials from which the wafer carriers are constructed. The primary drying gas is also treated by dissipating static electricity using the static suppressor 66. The filter, heated, and static electricity dissipated primary drying gas is then used by supplying it to the processing chamber 47. The flow of primary drying gas is developed by inducing the flow by rotating the rotor. The centrifugal action of the rotor thus sucks primary drying gas through the filter, plenum and heater and into and through the processing chamber. The induced flow of primary drying gas performs a drying function upon the wafer carriers being rotated within the processing chamber.

The wafer carriers are also preferably subjected to drying by supplying pressurized secondary drying gas to the outer

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and inner drying gas manifolds 100 and 120. The drying operation is enhanced by streaming or jetting the drying gases toward the wafer carriers while rotating the wafer carriers loaded upon the rotor. This simultaneous rotating and jetting with drying gas helps to expose the interstices of the wafer carriers to the drying action of the secondary drying gas as well as the primary drying gas. The secondary drying gas can be clean dry air, nitrogen or other suitable drying gas supplies having low contamination and low vapor content thus enhancing the rate of drying a speeding the overall processing rate. The wafer carriers are subjected to both primary and secondary drying for sufficient time to effectuate a dry condition on all surfaces of the wafer carriers.

The wafer carriers are further processed by stopping the rotor and incrementally positioning the wafer carrier supports 200 adjacent to the exit port 36. After the first wafer carrier support is positioned adjacent to exit port 36, the process includes opening exit door 35 using door operator 37. The wafer carrier support is then removed from the rotor by lifting the upper loop 219 clear of lug 206 and pivoting the wafer carrier support downwardly into the loading position shown in FIG. 11 at the right. The wafer carriers can then either be removed from the basket or the entire wafer carrier support can be removed and unloaded elsewhere as deemed best.

It is further noteworthy that the wafer carriers are loaded from a relatively less clean room, sometimes called a "grey room". The cleansed units are unloaded into a clean room having very low propensity for contaminating the cleaned wafer carriers. Thus the wafer carrier cleaning apparatus is preferably installed so that the entrance door operates in the grey room environment and the exit door operates in the clean room environment.

The wafer carrier cleaning apparatus is constructed using known welding, machining and other forming operations to provide the components and assemblies described in detail hereinabove. The processing chamber bowl and other conduits which supply gas or liquids are preferably made of stainless steel. Structural components can be made of steel or other suitable materials.

#### Industrial Applicability

The invention is useful for cleaning wafer carriers, boxes for holding wafer carriers, and analogous articles requiring very low contaminant levels.

We claim:

1. A centrifugal cleaner for cleaning carriers used in semiconductor processing, comprising:

a frame;

a processing vessel defining a process chamber there-within;

at least one port to allow passage of carriers relative to the process chamber; said port being formed in a sidewall of the processing vessel;

at least one door for controllably opening and closing said port;

a rotor mounted for rotation within the process chamber; at least one carrier support which is accessible through said at least one port; said at least one carrier support being connected to said rotor for holding carriers during centrifugal cleaning;

rotor drive means for controllably rotating said rotor;

a plurality of outer supplies for directing fluid against the at least one carrier support from positions outward of the carrier support;

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a plurality of inner supplies for directing fluid against the at least one carrier support from positions inward of the carrier support;

at least one drying gas supply for supplying drying gas to the process chamber to dry said cleaning liquid from carriers.

2. A centrifugal cleaner for carriers according to claim 1 and wherein the rotor extends upwardly from lower portions of the processing chamber.

3. A centrifugal cleaner for carriers according to claim 1 and wherein the rotor extends upwardly from lower portions of the processing chamber within a rotor support housing mounted within the processing chamber.

4. A centrifugal cleaner for carriers according to claim 1 and wherein said plurality of outer and inner supplies includes at least one outer sprayer for spraying from an outer position inwardly toward carriers held in the carrier supports, and at least one inner sprayer for spraying from an inner position outwardly toward carriers held in the carrier supports.

5. A centrifugal cleaner for carriers according to claim 1 and wherein the rotor extends upwardly from lower portions of the processing chamber within a rotor support housing mounted within the processing chamber; said rotor also including a rotor wheel having openings therein along upper portions thereof; said rotor further including a rotor cage which is mounted to said rotor wheel and extends downwardly to support said plurality of carrier supports.

6. A centrifugal cleaner for carriers according to claim 1 and wherein the rotor extends upwardly from lower portions of the processing chamber within a rotor support housing mounted within the processing chamber; said rotor also including a rotor wheel along upper portions thereof; said rotor further including a rotor cage which is mounted to said rotor wheel and extends downwardly; and wherein said plurality of outer and inner supplies includes a plurality of cleaning liquid sprayer manifolds; said sprayer manifolds including outer sprayer manifolds for spraying from outer positions inwardly toward carriers held in the carrier supports, and inner sprayer manifolds for spraying from inner positions outwardly toward carriers held in the carrier supports; said inner sprayer manifolds extending upwardly within the processing chamber between the rotor cage and the rotor support housing.

7. A centrifugal cleaner for carriers according to claim 1 and wherein the rotor extends upwardly from lower portions of the processing chamber; said rotor further including a rotor cage to support said plurality of carrier supports.

8. A centrifugal cleaner for carriers according to claim 1 and wherein the rotor includes a rotor shaft which extends upwardly from lower portions of the processing chamber; said rotor further including a rotor cage having downwardly extending portions; said plurality of outer and inner supplies includes multiple spray manifolds including at least one inner spray manifold which extends upwardly within the processing chamber between the rotor cage and the rotor shaft, and at least one outer spray manifold which is outward from the rotor cage.

9. A centrifugal cleaner for carriers according to claim 1 and wherein the rotor includes portions which induce air flow through the vessel.

10. A centrifugal cleaner for carriers according to claim 1 and wherein the rotor includes a rotor shaft which extends upwardly from lower portions of the processing chamber; said rotor further including a rotor cage having downwardly extending portions; said plurality of inner supplies being positioned to extend within the rotor cage.



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11. A centrifugal cleaner for carriers according to claim 1 and further comprising at least one drying gas filter for filtering contaminants from drying gas supplied to the process chamber through said at least one drying gas supply.

12. A centrifugal cleaner for carriers according to claim 1 and further comprising:

- at least one drying gas filter for filtering contaminants from drying gas supplied to the process chamber through said at least one drying gas supply;
- at least one drying gas heater for heating drying gas supplied to the process chamber through said at least one drying gas supply.

13. A centrifugal cleaner for carriers according to claim 1 and further comprising:

- a drying gas plenum;
- at least one drying gas filter for filtering contaminants from drying gas supplied to said drying gas plenum;
- at least one drying gas heater mounted to the drying gas plenum for heating filtered drying gas;
- and wherein filtered, heated drying gas from said plenum is supplied to the process chamber.

14. A centrifugal cleaner for carriers according to claim 1 and wherein at least one drying gas supply is approximately aligned with the rotational axis of said rotor.

15. A centrifugal cleaner for carriers according to claim 1 wherein said plurality of outer and inner supplies includes a plurality of spray manifolds; and further comprising a plurality of drying gas manifolds for jetting drying gas upon the carrier supports and any carriers held therein to aid in drying cleaning liquid therefrom.

16. A centrifugal cleaner for carriers according to claim 1 and wherein said plurality of outer and inner supplies includes:

- a plurality of spray manifolds; said spray manifolds including outer spray manifolds for spraying from outer positions inwardly toward carriers held in the carrier supports, and inner spray manifolds for spraying from inner positions outwardly toward carriers held in the carrier supports; and
- a plurality of drying gas manifolds for jetting drying gas upon the carrier supports and any carriers held therein to aid in drying cleaning liquid therefrom.

17. A centrifugal cleaner for carriers according to claim 1 and further defined by said at least one door being slidable.

18. A centrifugal cleaner for carriers according to claim 1 wherein there are distinct entrance and exit ports, and distinct entrance and exit doors which controllably open and close said ports, respectively.

19. A centrifugal cleaner for carriers according to claim 1 wherein there are distinct entrance and exit ports, and distinct entrance and exit doors which controllably open and close said ports, respectively; said entrance and exit doors being slidable.

20. A centrifugal cleaner for cleaning carriers used in semiconductor processing, comprising:

- a frame;
- a processing vessel defining a process chamber there-within;
- at least one port to allow passage of carriers relative to the process chamber;
- at least one door for controllably opening and closing said port;
- a rotor mounted for rotation within the process chamber;
- at least one carrier support connected to said rotor for holding carriers during centrifugal cleaning;

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rotor drive means for controllably rotating said rotor; at least one cleaning liquid sprayer mounted within the process chamber for spraying a suitable cleaning liquid upon carriers held in the carrier supports;

at least one primary drying gas supply for supplying primary drying gas to the process chamber to dry said cleaning liquid from carriers; said at least one primary drying gas supply including at least one port through which drying gas flows from upper portions of the process chamber downwardly;

at least one secondary drying gas supply for jetting secondary drying gas onto carriers held in the at least one carrier support.

21. A centrifugal cleaner for carriers according to claim 20 and further comprising at least one drying gas filter for filtering contaminants from drying gas supplied to the process chamber through said at least one primary drying gas supply.

22. A centrifugal cleaner for carriers according to claim 20 and further comprising:

- at least one drying gas filter for filtering contaminants from drying gas supplied to the process chamber through said at least one primary drying gas supply;
- at least one drying gas heater for heating drying gas supplied to the process chamber through said at least one primary drying gas supply.

23. A centrifugal cleaner for carriers according to claim 20 and further comprising:

- a drying gas plenum;
- at least one drying gas filter for filtering contaminants from drying gas supplied to said drying gas plenum;
- at least one drying gas heater mounted to the drying gas plenum for heating filtered drying gas;
- and wherein filtered, heated drying gas from said plenum is supplied to the process chamber through said at least one primary drying gas supply.

24. A centrifugal cleaner for carriers according to claim 20 and wherein said at least one primary drying gas supply is approximately aligned with the rotational axis of said rotor.

25. A centrifugal cleaner for carriers according to claim 20 and wherein the rotor extends upwardly from lower portions of the processing chamber.

26. A centrifugal cleaner for carriers according to claim 20 and wherein the rotor extends upwardly from lower portions of the processing chamber within a rotor support housing mounted within the processing chamber.

27. A centrifugal cleaner for carriers according to claim 20 and wherein the rotor extends upwardly from lower portions of the processing chamber within a rotor support housing mounted within the processing chamber; said rotor also including a rotor wheel having openings therein along upper portions thereof; said rotor further including a rotor cage which is mounted to said rotor wheel and extends downwardly to support said plurality of carrier supports.

28. A centrifugal cleaner for carriers according to claim 20 and wherein the rotor extends upwardly from lower portions of the processing chamber within a rotor support housing mounted within the processing chamber; said rotor also including a rotor wheel along upper portions thereof; said rotor further including a rotor cage which is mounted to said rotor wheel and extends downwardly; said at least one cleaning liquid sprayer including at least one inner spray manifold which extends upwardly within the processing chamber between the rotor cage and the rotor support housing.

29. A centrifugal cleaner for carriers according to claim 20 and wherein the rotor extends upwardly from lower portions



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of the processing chamber; said rotor further including a rotor cage to support said plurality of carrier supports.

30. A centrifugal cleaner for carriers according to claim 20 and wherein the rotor includes a rotor shaft which extends upwardly from lower portions of the processing chamber; said rotor further including a rotor cage having downwardly extending portions; said at least one cleaning liquid sprayer having multiple spray manifolds including at least one inner spray manifold which extends upwardly within the processing chamber between the rotor cage and the rotor shaft.

31. A centrifugal cleaner for carriers according to claim 20 and wherein the rotor includes a rotor shaft; said rotor further including a rotor cage; said at least one cleaning liquid sprayer having multiple spray manifolds including at least one inner spray manifold which extends upwardly within the processing chamber between the rotor cage and the rotor shaft, and at least one outer spray manifold which is outward from the rotor cage.

32. A centrifugal cleaner for carriers according to claim 20 and wherein said at least one cleaning liquid sprayer includes a plurality of spray manifolds; said spray manifolds including outer spray manifolds for spraying from outer positions inwardly toward carriers held in the carrier supports, and inner spray manifolds for spraying from inner positions outwardly toward carriers held in the carrier supports.

33. A centrifugal cleaner for carriers according to claim 20 wherein said at least one cleaning liquid sprayer includes a plurality of spray manifolds; and further comprising a plurality of secondary drying gas manifolds for jetting drying gas upon the carrier supports and any carriers held therein to aid in drying cleaning liquid therefrom.

34. A centrifugal cleaner for carriers according to claim 20 and wherein said at least one cleaning liquid sprayer includes a plurality of spray manifolds; said spray manifolds including outer spray manifolds for spraying from outer positions inwardly toward carriers held in the carrier supports, and inner spray manifolds for spraying from inner positions outwardly toward carriers held in the carrier supports; and said at least one secondary drying gas supply further comprising a plurality of drying gas manifolds for jetting drying gas upon the carrier supports and any carriers held therein to aid in drying cleaning liquid therefrom.

35. A centrifugal cleaner for carriers according to claim 20 and further comprising a lower baffle spaced from and adjacent to a bottom of the process chamber.

36. A centrifugal cleaner for carriers according to claim 20 and further defined by said at least one door being slidable.

37. A centrifugal cleaner for carriers according to claim 20 wherein there are distinct entrance and exit ports, and distinct entrance and exit doors which controllably open and close said ports, respectively.

38. A centrifugal cleaner for carriers according to claim 20 wherein there are distinct entrance and exit ports, and distinct entrance and exit doors which controllably open and close said ports, respectively; said entrance and exit doors being slidable.

39. A centrifugal cleaner for cleaning carriers used in semiconductor processing, comprising:

a frame;

a processing vessel defining a process chamber there-within;

at least one port to allow passage of carriers relative to the process chamber;

a door for controllably opening and closing said port;

a rotor mounted for rotation within the process chamber;

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at least one carrier support connected to said rotor for holding carriers during centrifugal cleaning;

rotor drive means for controllably rotating said rotor;

at least one cleaning liquid sprayer mounted within the process chamber for spraying a suitable cleaning liquid upon carriers held in the carrier supports;

at least one primary drying gas supply for supplying primary drying gas to the process chamber to dry said cleaning liquid from carriers;

said rotor being arranged within the processing chamber and constructed so as to induce flow of primary drying gas through the at least one primary drying gas supply and through the processing chamber when the rotor is rotating.

40. A centrifugal cleaner for carriers according to claim 39 and further comprising at least one drying gas filter for filtering contaminants from drying gas supplied to the process chamber through said at least one primary drying gas supply.

41. A centrifugal cleaner for carriers according to claim 39 and further comprising:

at least one drying gas filter for filtering contaminants from primary drying gas supplied to the process chamber through said at least one primary drying gas supply;

at least one drying gas heater for heating drying gas supplied to the process chamber.

42. A centrifugal cleaner for carriers according to claim 39 and further comprising:

a drying gas plenum;

at least one drying gas filter for filtering contaminants from drying gas supplied to said drying gas plenum;

at least one drying gas heater mounted to the drying gas plenum for heating filtered drying gas;

and wherein filtered, heated drying gas from said plenum is supplied to the process chamber through said at least one primary drying gas supply.

43. A centrifugal cleaner for carriers according to claim 39 and wherein said at least one primary drying gas supply is approximately aligned with the rotational axis of said rotor.

44. A centrifugal cleaner for carriers according to claim 39 and wherein the rotor extends upwardly from lower portions of the processing chamber.

45. A centrifugal cleaner for carriers according to claim 39 and wherein the rotor extends upwardly from lower portions of the processing chamber within a rotor support housing mounted within the processing chamber.

46. A centrifugal cleaner for carriers according to claim 39 and wherein the rotor extends upwardly from lower portions of the processing chamber within a rotor support housing mounted within the processing chamber; said rotor also including a rotor wheel having openings thereon along upper portions thereof; said rotor further including a rotor cage which is mounted to said rotor wheel and extends downwardly to support said plurality of carrier supports.

47. A centrifugal cleaner for carriers according to claim 39 and wherein the rotor extends upwardly from lower portions of the processing chamber within a rotor support housing mounted within the processing chamber; said rotor also including a rotor wheel having openings along upper portions thereof; said rotor further including a rotor cage which is mounted to said rotor wheel and extends downwardly; said at least one cleaning liquid sprayer including at least one inner spray manifold which extends upwardly within the processing chamber between the rotor cage and the rotor support housing.

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48. A centrifugal cleaner for carriers according to claim 39 and wherein the rotor extends upwardly from lower portions of the processing chamber; said rotor further including a rotor cage to support said plurality of carrier supports.

49. A centrifugal cleaner for carriers according to claim 39 and wherein the rotor includes a rotor shaft which extends upwardly from lower portions of the processing chamber; said rotor further including a rotor cage having downwardly extending portions; said at least one cleaning liquid sprayer having multiple spray manifolds including at least one inner spray manifold which extends upwardly within the processing chamber between the rotor cage and the rotor shaft.

50. A centrifugal cleaner for carriers according to claim 39 and wherein the rotor includes a rotor shaft; said rotor further including a rotor cage; said at least one cleaning liquid sprayer having multiple spray manifolds including at least one inner spray manifold which extends upwardly within the processing chamber between the rotor cage and the rotor shaft, and at least one outer spray manifold which is outward from the rotor cage.

51. A centrifugal cleaner for carriers according to claim 39 and wherein said at least one cleaning liquid sprayer includes a plurality of spray manifolds; said spray manifolds including outer spray manifolds for spraying from outer positions inwardly toward carriers held in the carrier supports, and inner spray manifolds for spraying from inner positions outwardly toward carriers held in the carrier supports.

52. A centrifugal cleaner for carriers according to claim 39 wherein said at least one cleaning liquid sprayer includes a plurality of spray manifolds; and further comprising a plu-

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ality of secondary drying gas manifolds for jetting drying gas upon the carrier supports and any carriers held therein to aid in drying cleaning liquid therefrom.

53. A centrifugal cleaner for carriers according to claim 39 and wherein said at least one cleaning liquid sprayer includes a plurality of spray manifolds; said spray manifolds including outer spray manifolds for spraying from outer positions inwardly toward carriers held in the carrier supports, and inner spray manifolds for spraying from inner positions outwardly toward carriers held in the carrier supports; and said at least one secondary drying gas supply further comprising a plurality of drying gas manifolds for jetting drying gas upon the carrier supports and any carriers held therein to aid in drying cleaning liquid therefrom.

54. A centrifugal cleaner for carriers according to claim 39 and further comprising a lower baffle spaced from and adjacent to a bottom of the process chamber.

55. A centrifugal cleaner for carriers according to claim 39 and further defined by said at least one door being slidable.

56. A centrifugal cleaner for carriers according to claim 39 wherein there are distinct entrance and exit ports, and distinct entrance and exit doors which controllably open and close said ports, respectively.

57. A centrifugal cleaner for carriers according to claim 39 wherein there are distinct entrance and exit ports, and distinct entrance and exit doors which controllably open and close said ports, respectively; said entrance and exit doors being slidable.

\* \* \* \* \*

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 5,562,113  
DATED : October 8, 1996  
INVENTOR(S) : Thompson et al.

Page 1 of 2

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the title page, at column 2, last line thereof, change "13" to --14--.

At the top of each of drawing sheets 1-13, change "1 of 13" to -- 1 of 14--.

Column 9, line 11, change "addition" to --additional--.

Column 10, line 6, insert --and-- between "extends" and "is".

Column 10, line 15, delete the first occurrence of [is].

Column 11, line 10, delete [a] and insert --and--.

Column 12, line 16, delete the second occurrence of [includes].

Signed and Sealed this  
Second Day of June, 1998

Attest:



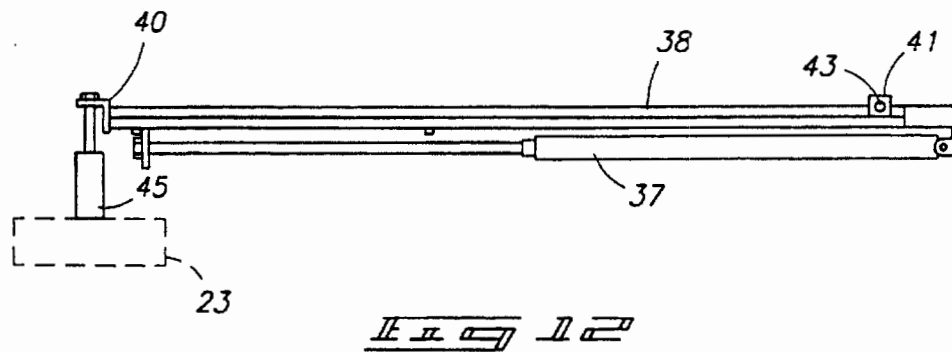
BRUCE LEHMAN

Attesting Officer

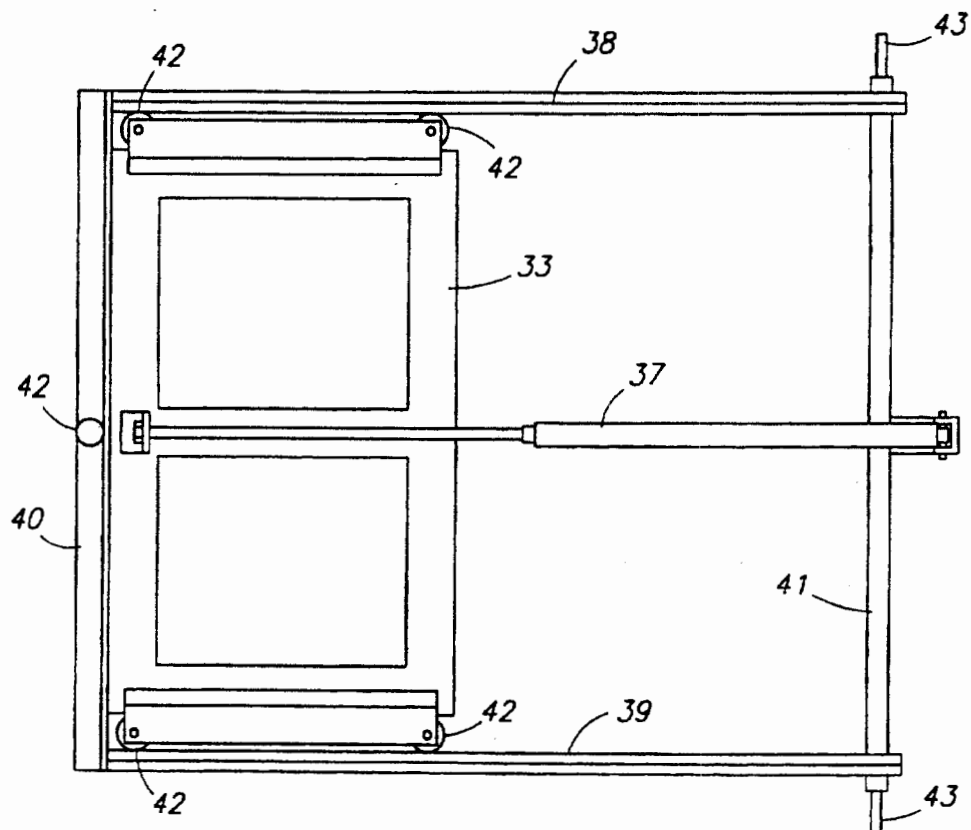
Commissioner of Patents and Trademarks

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14/14



*FIG. 14*



*FIG. 15*







US005972127A

**United States Patent** [19]

Thompson et al.

[11] **Patent Number:** 5,972,127[45] **Date of Patent:** \*Oct. 26, 1999[54] **METHODS FOR CENTRIFUGALLY  
CLEANING WAFER CARRIERS**[76] Inventors: **Raymon F. Thompson; Aleksander  
Owczarz**, both of P.O. Box 7010,  
Kalispell, Mont. 59904

[\*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

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[22] Filed: Nov. 26, 1997

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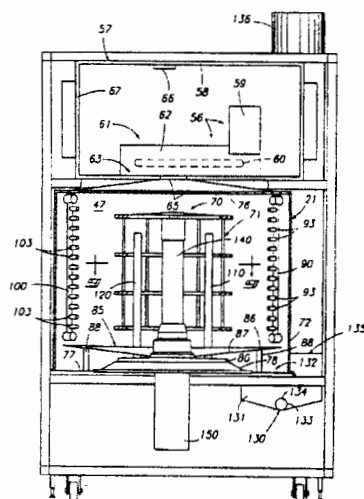
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[51] Int. Cl.<sup>6</sup> ..... **B08B 3/02; B08B 5/00**[52] U.S. Cl. .... **134/33; 134/37; 134/95.2;**  
134/95.3; 134/99.1; 134/103.2; 134/153;  
134/902*Primary Examiner*—Zeinab El-Arini  
*Attorney, Agent, or Firm*—Lyon & Lyon LLP[58] **Field of Search** ..... 134/32, 33, 37,  
134/95.2, 95.3, 99.1, 103.2, 153, 902[57] **ABSTRACT**[56] **References Cited****U.S. PATENT DOCUMENTS**

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A process for cleaning carriers used to hold semiconductor articles includes loading a carrier on a rotor within a processing chamber. The rotor is rotated while spraying cleaning liquid onto the carrier. A flow of primary drying gas is induced through the processing chamber via the centrifugal action of the rotor. Secondary drying gas is sprayed onto the carriers from nozzles. Carriers are loaded onto carrier supports on the rotor, and are held in place with removable baskets.

**38 Claims, 14 Drawing Sheets**

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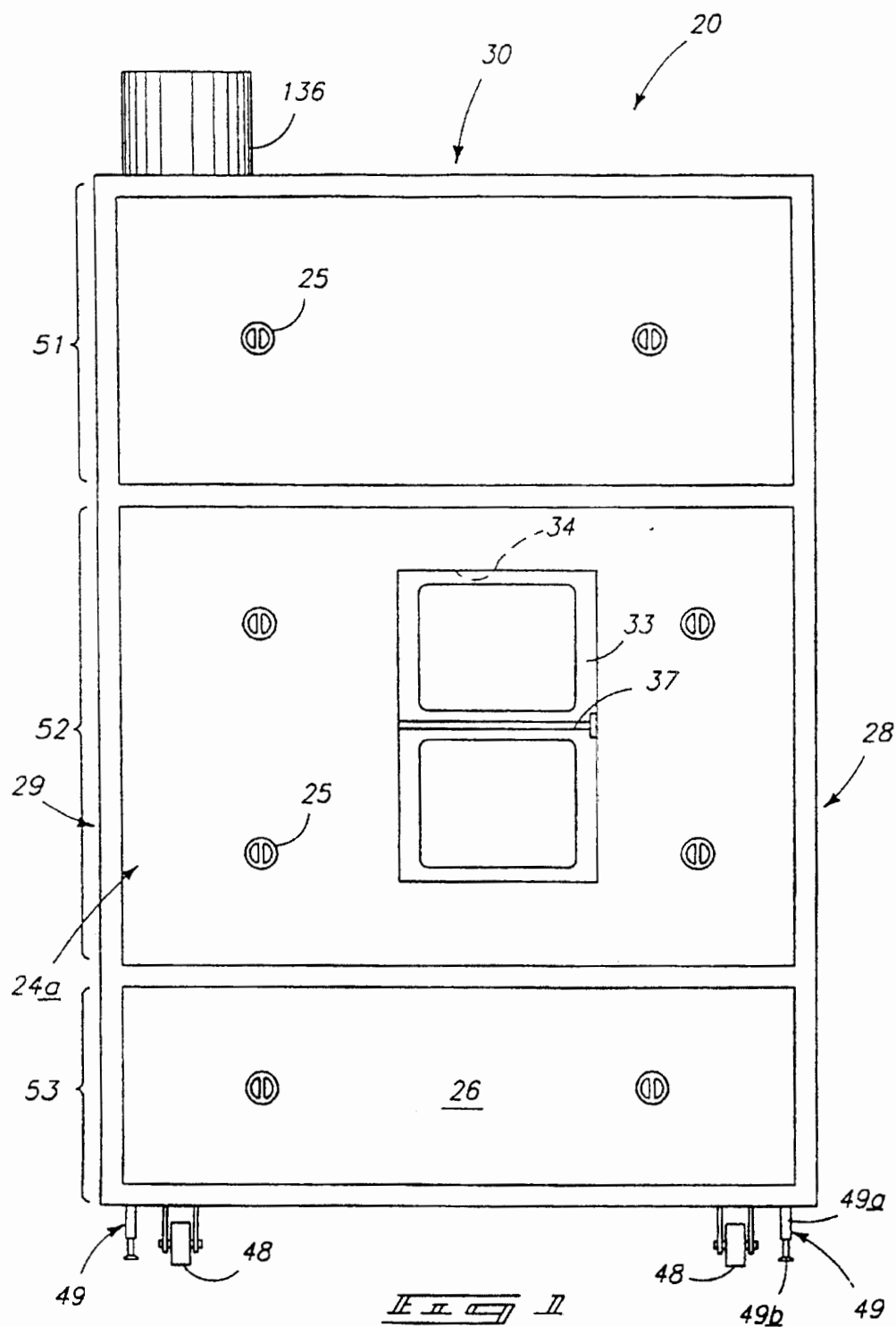


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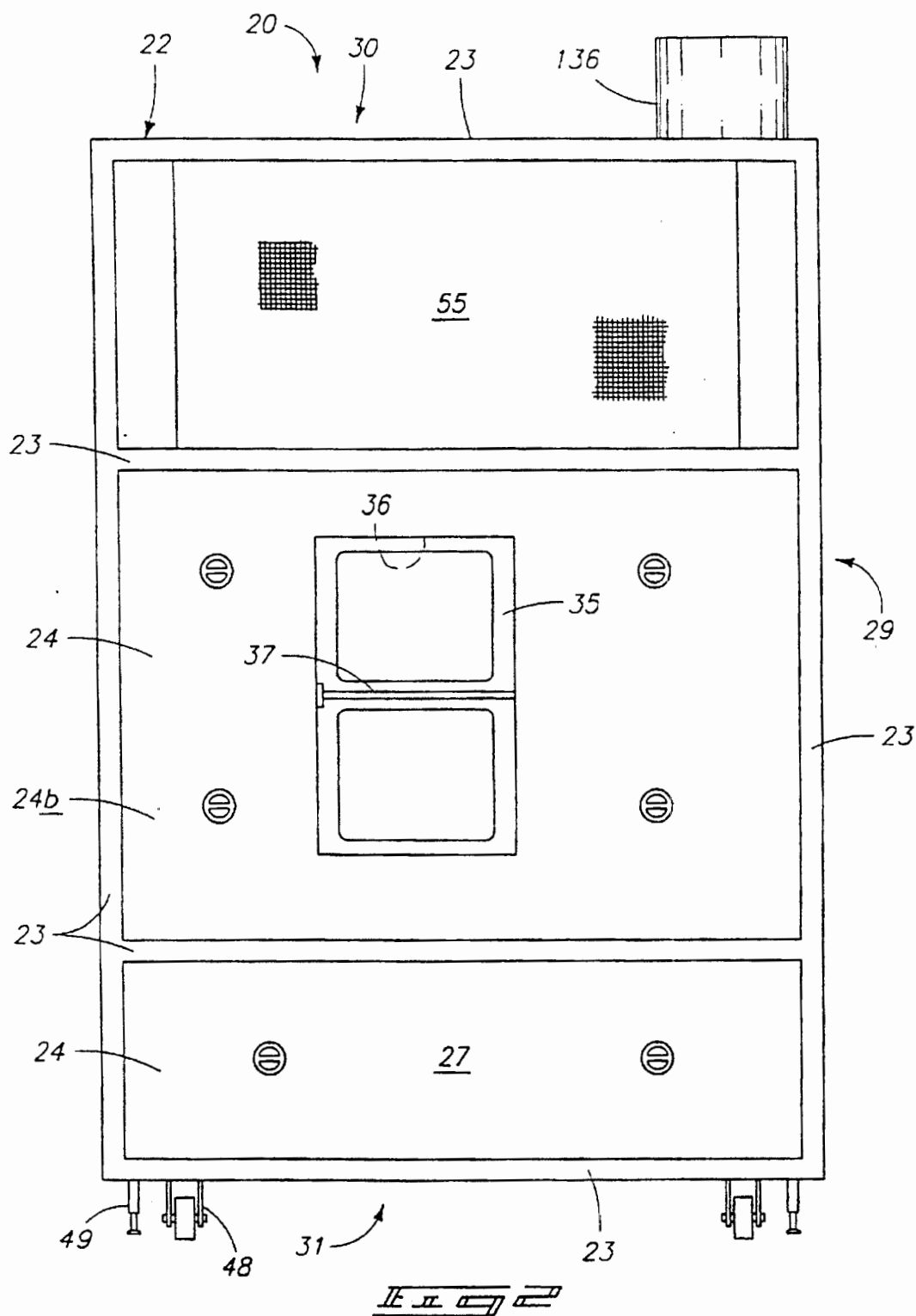


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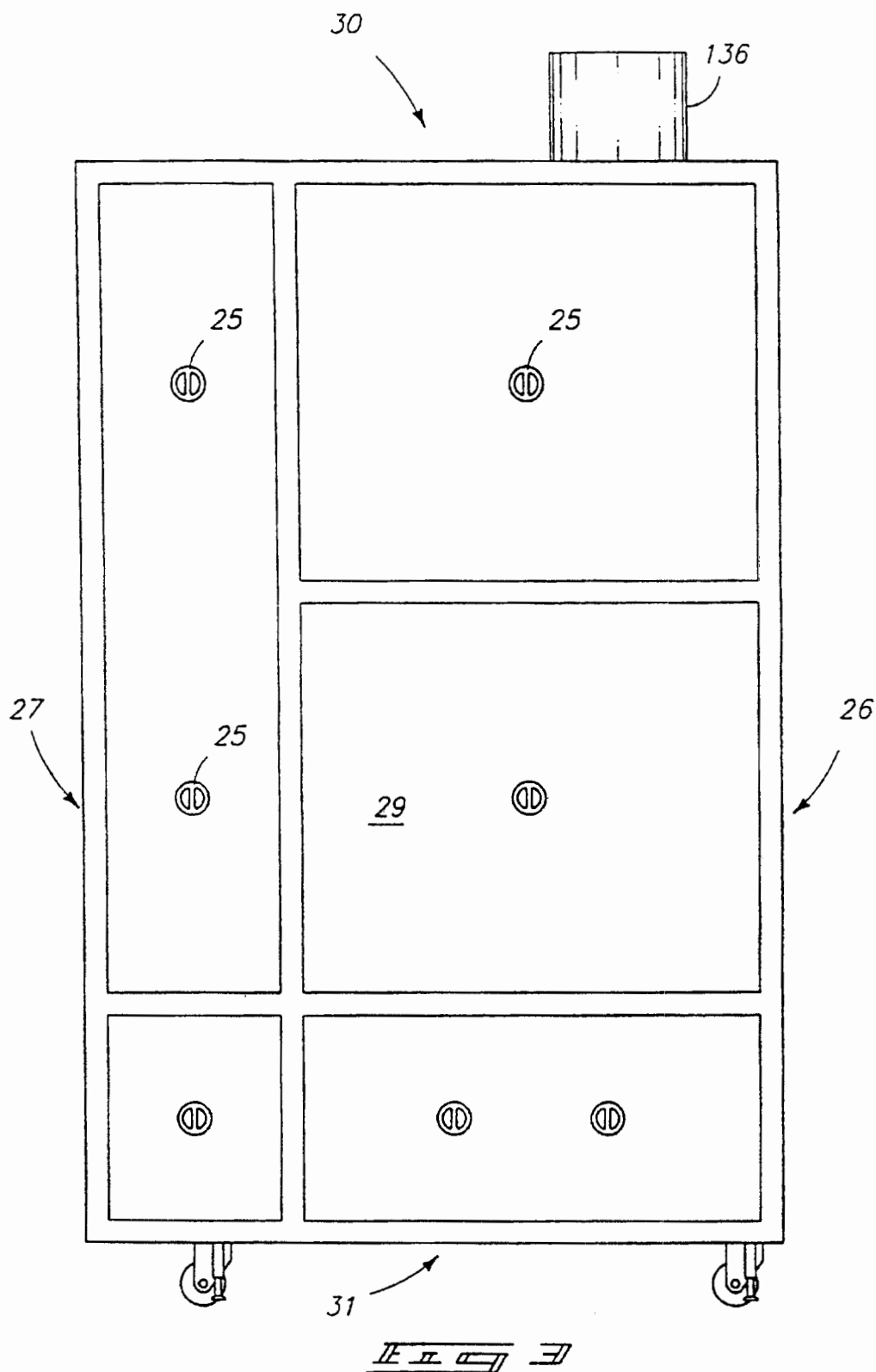


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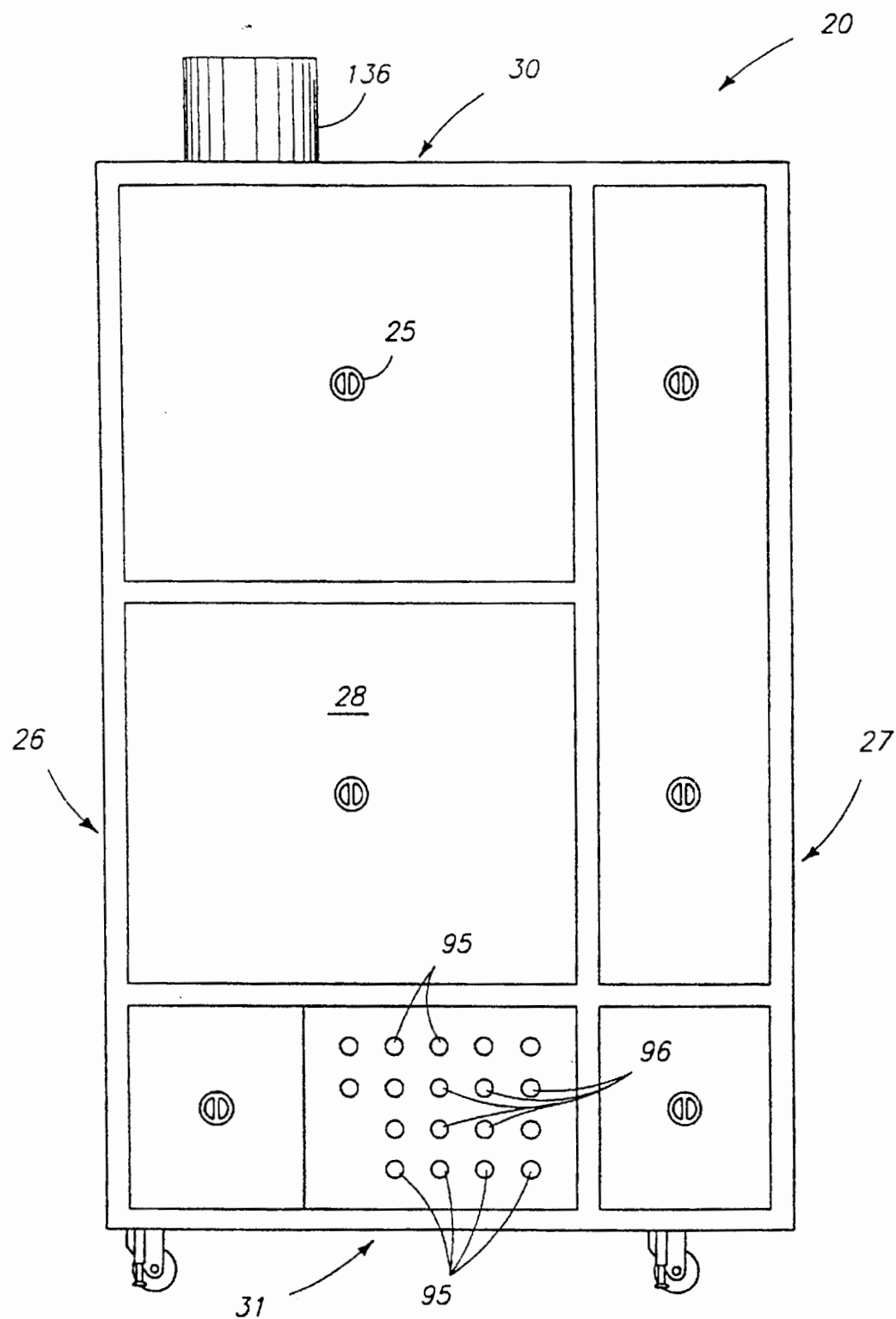


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*FIG. 4*

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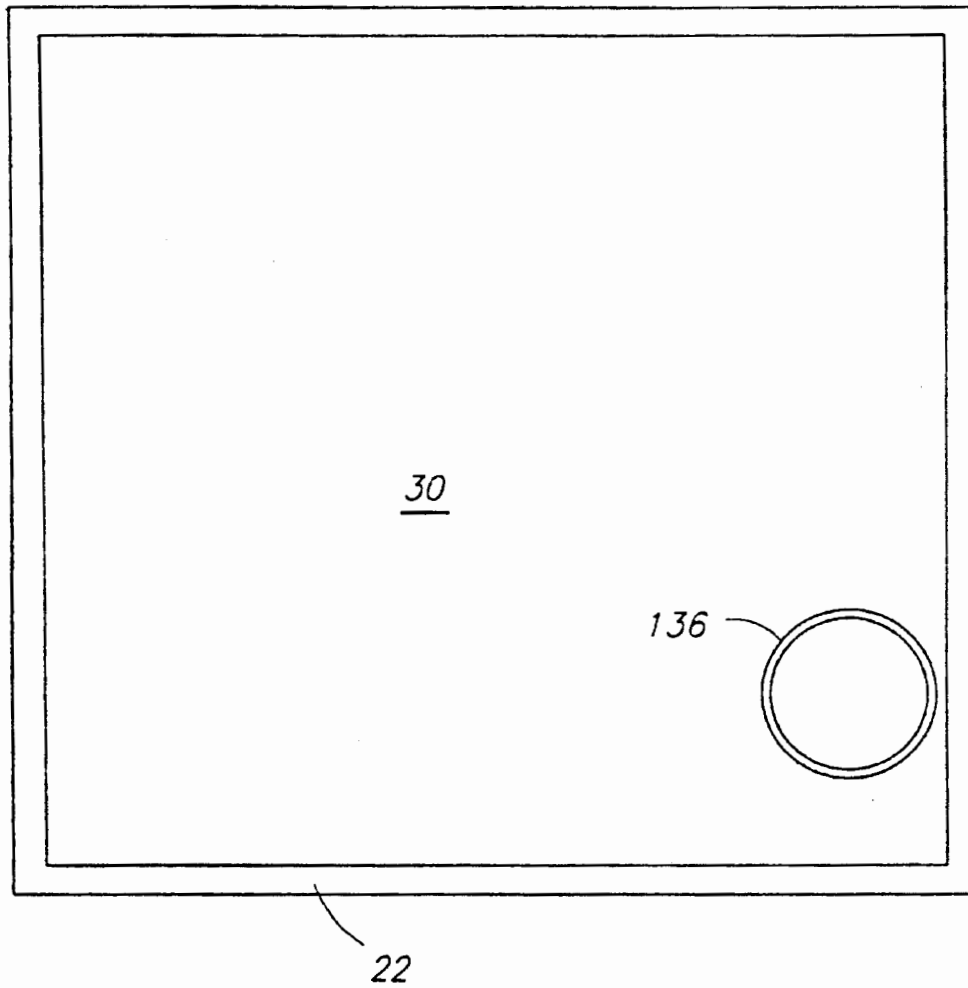


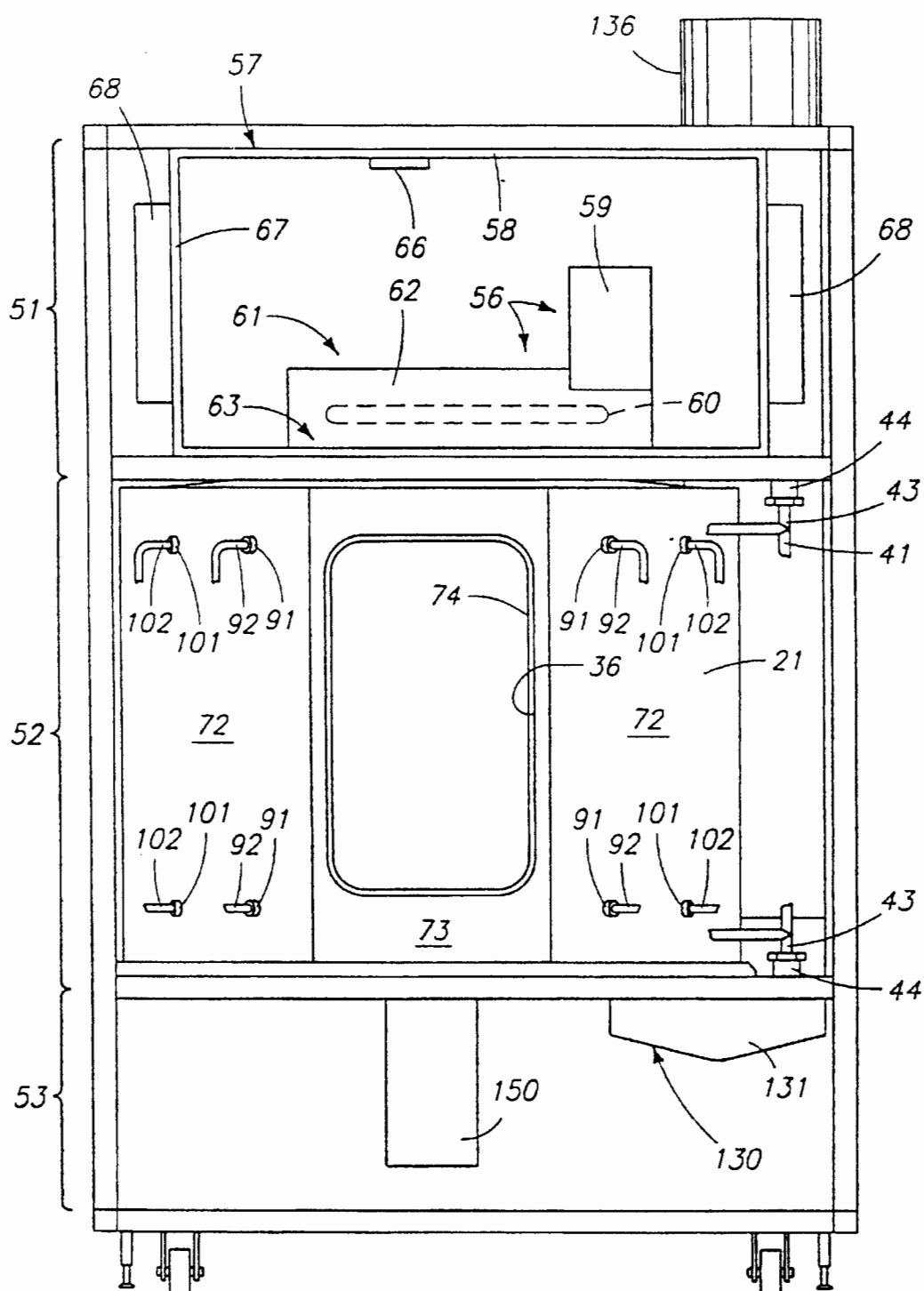
FIG. 5

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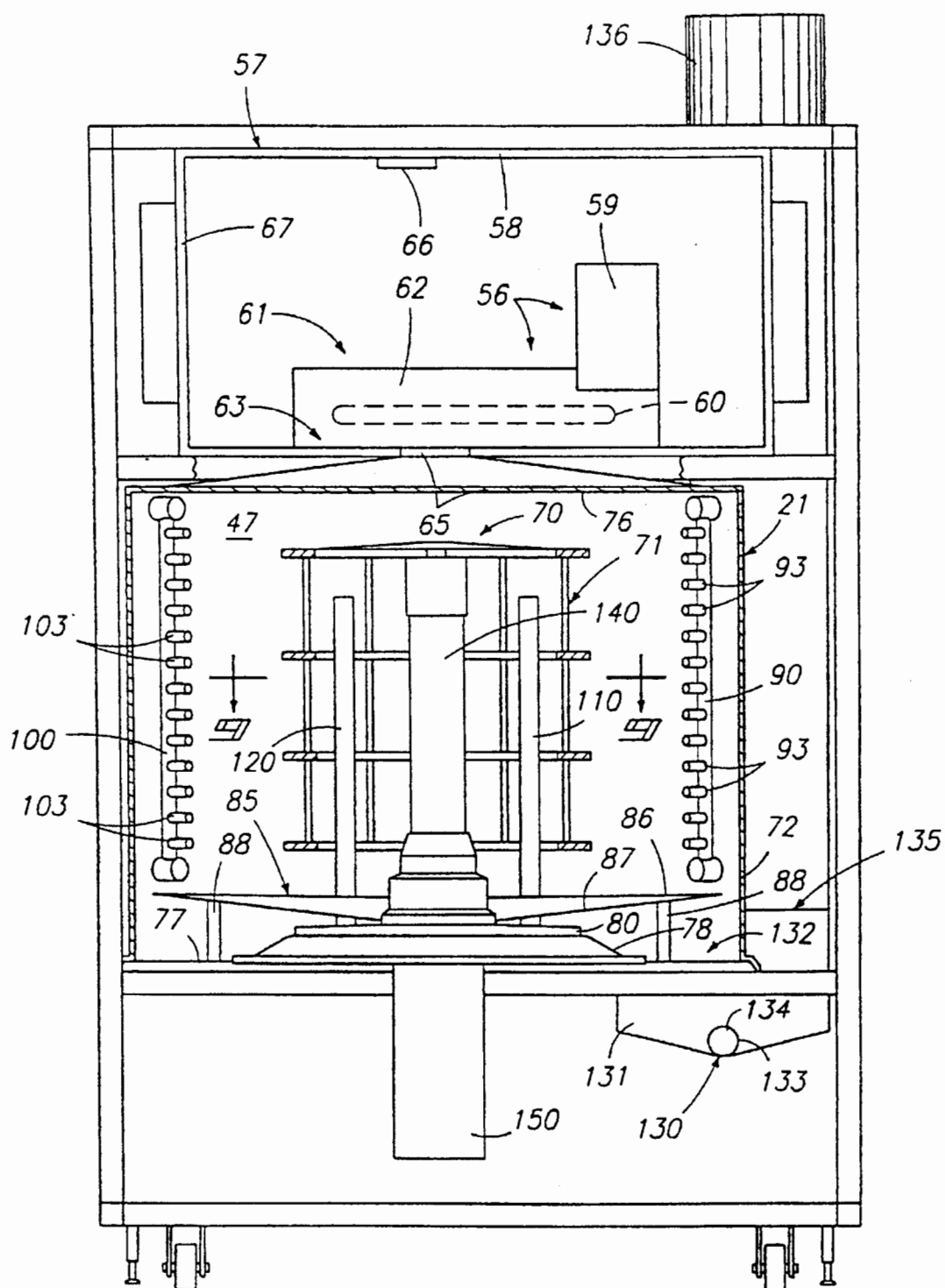


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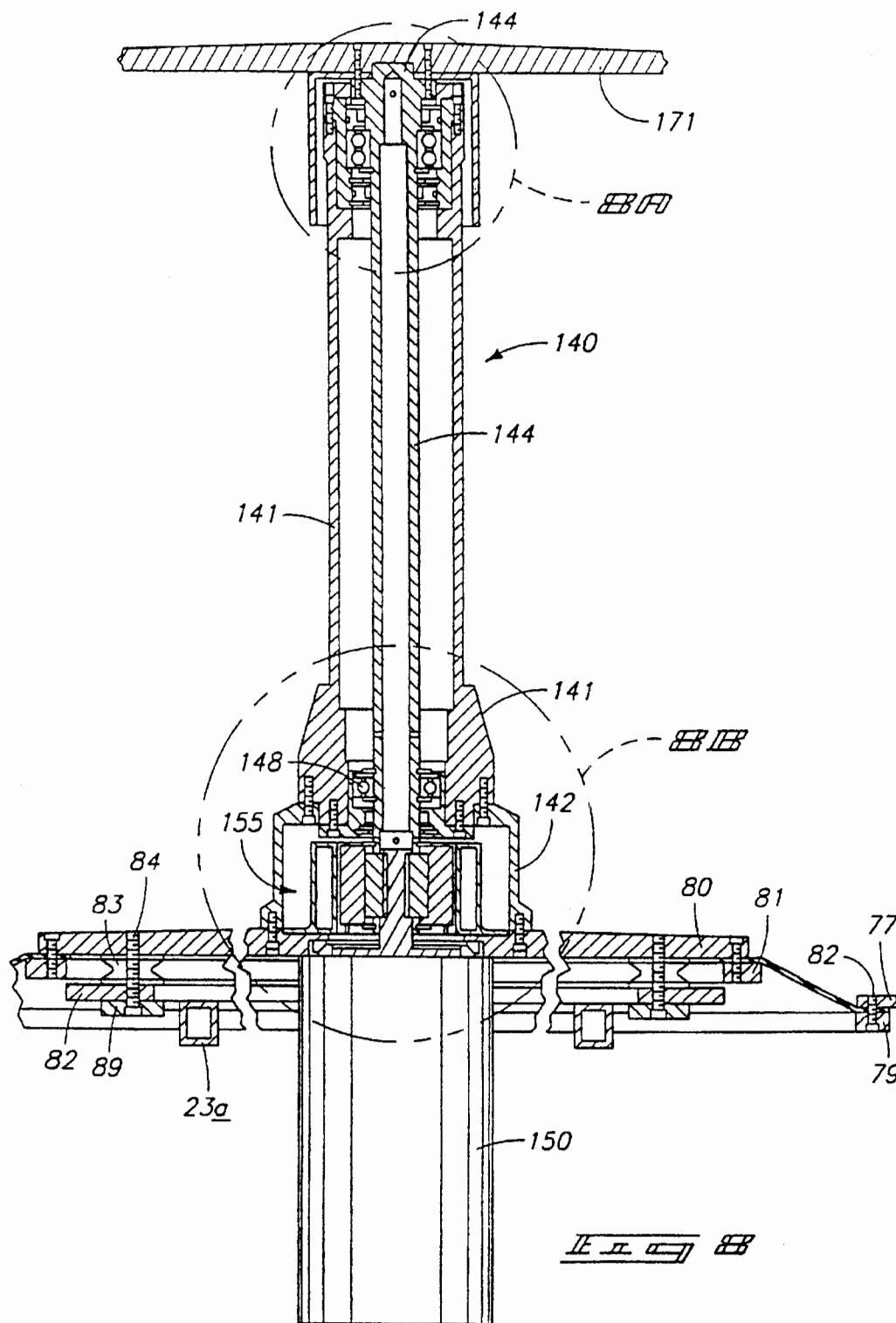
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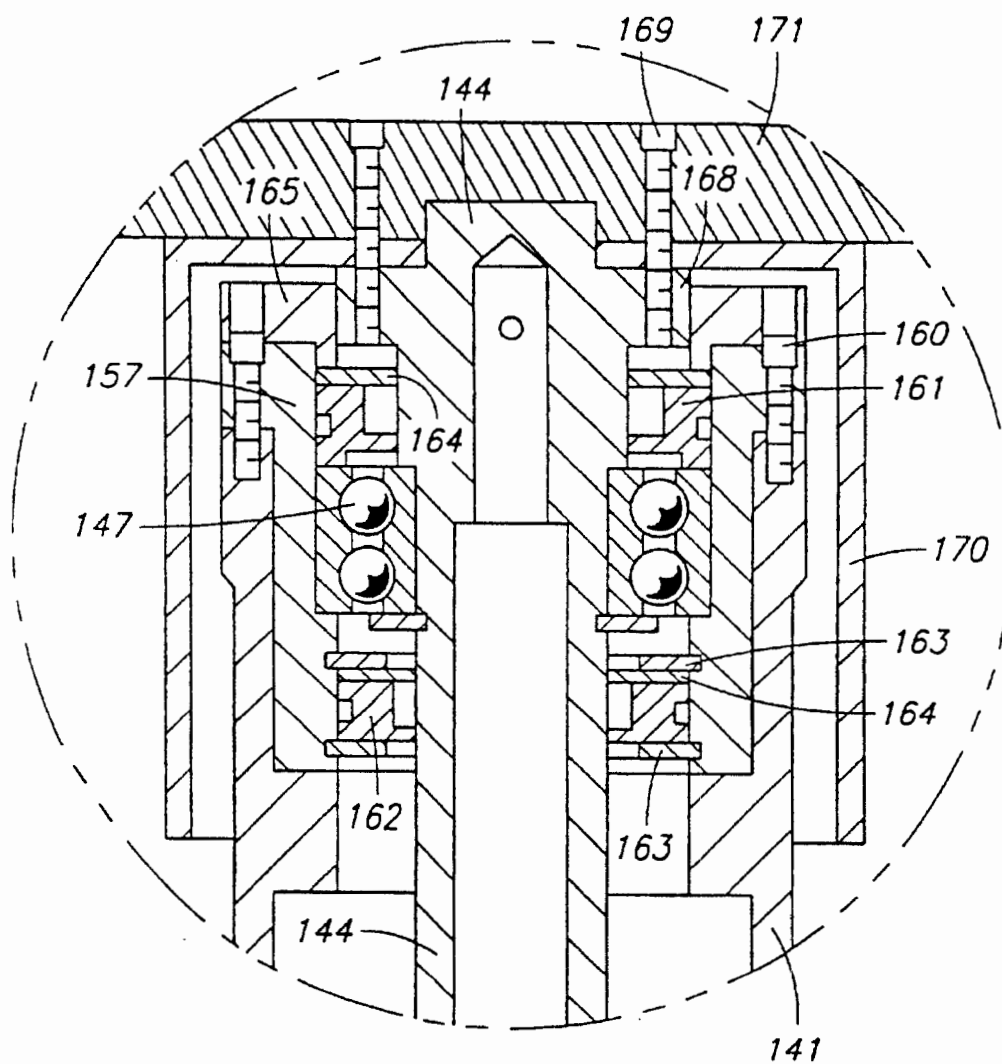


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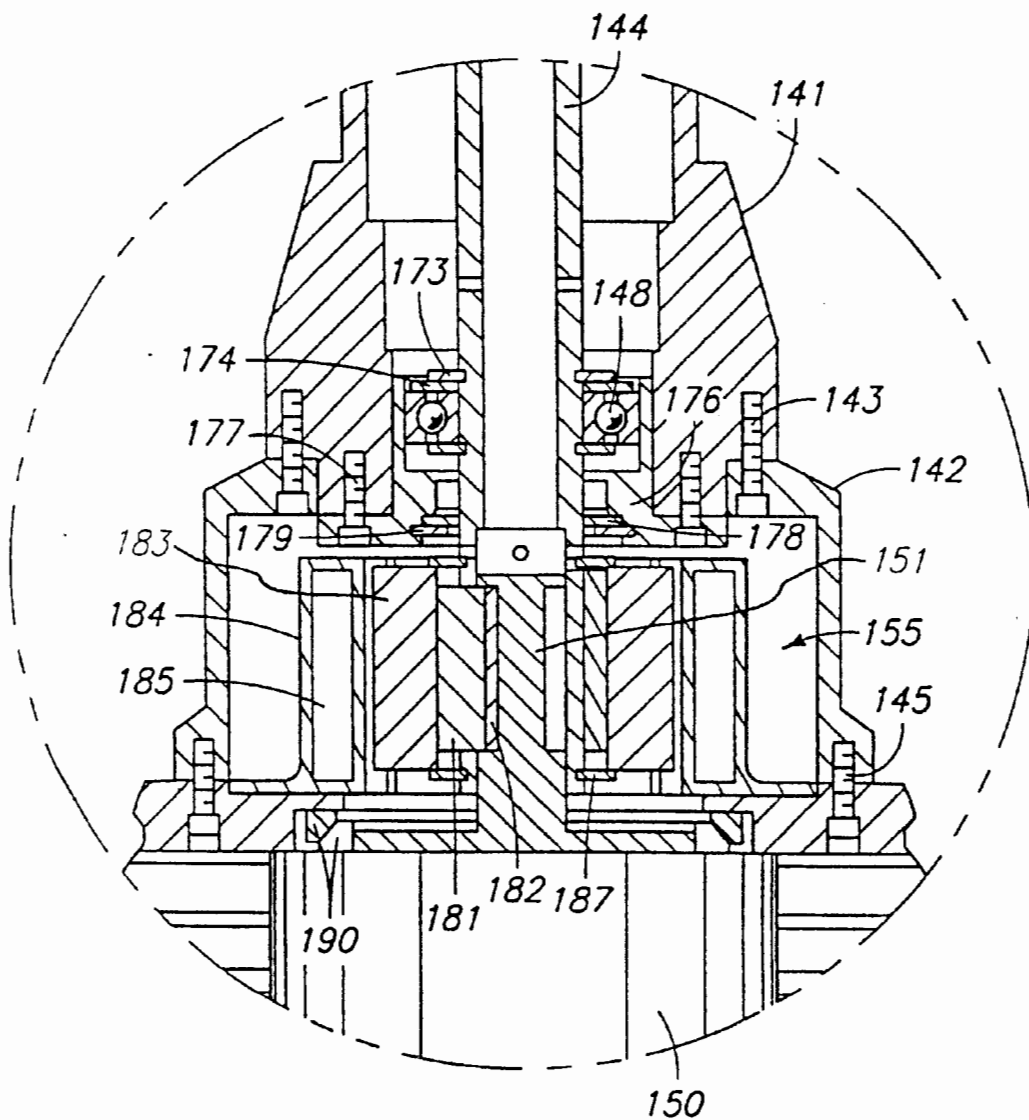
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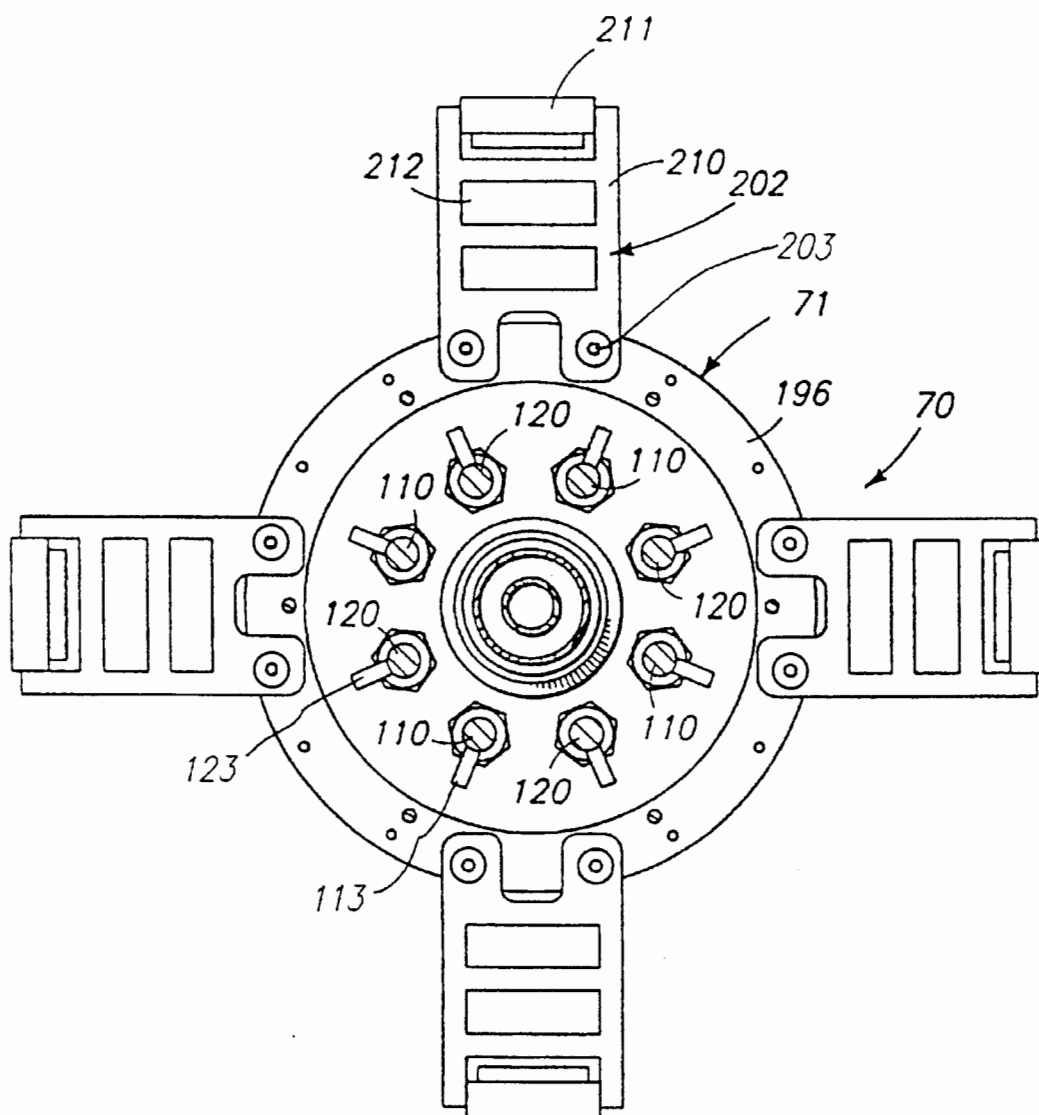


FIG. 9

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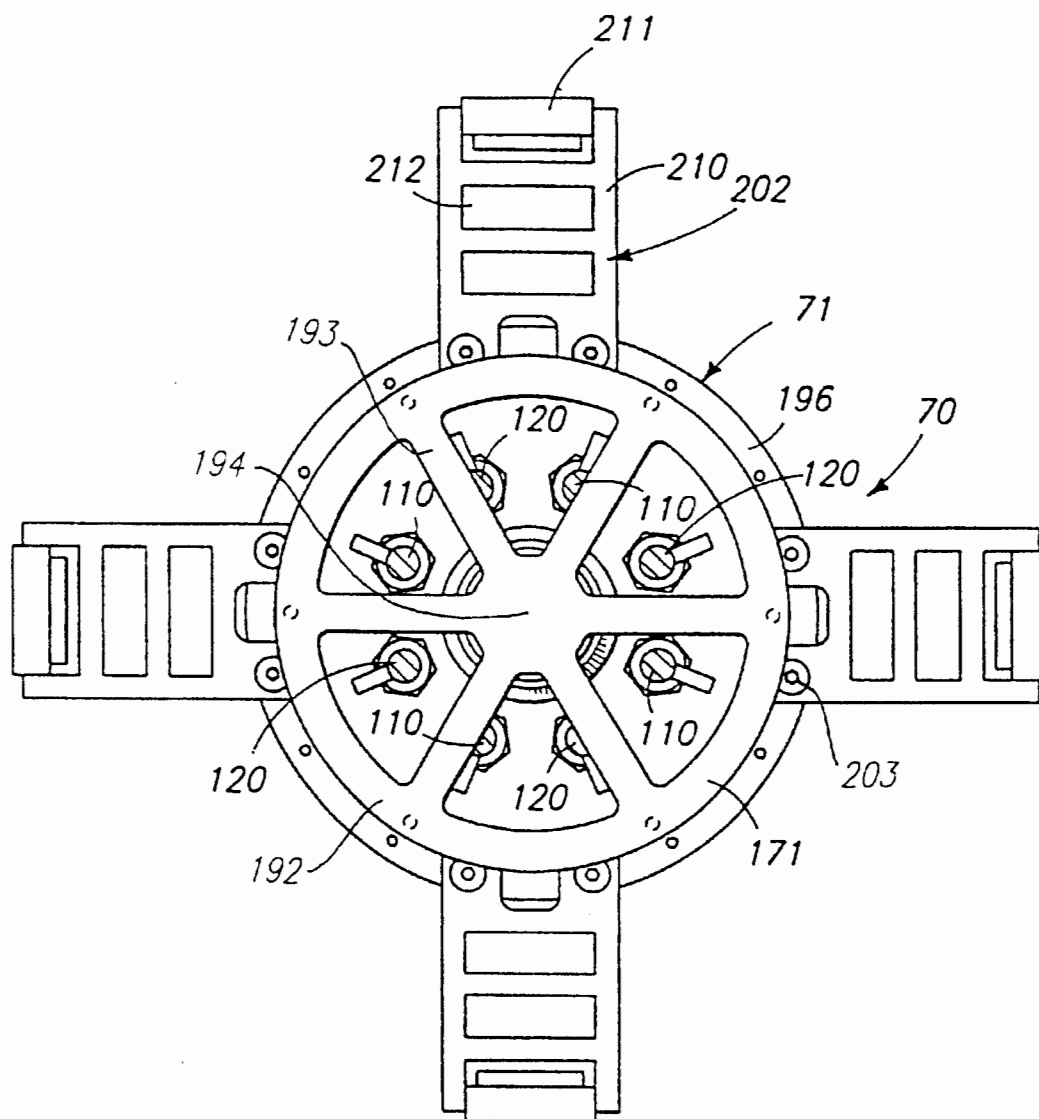


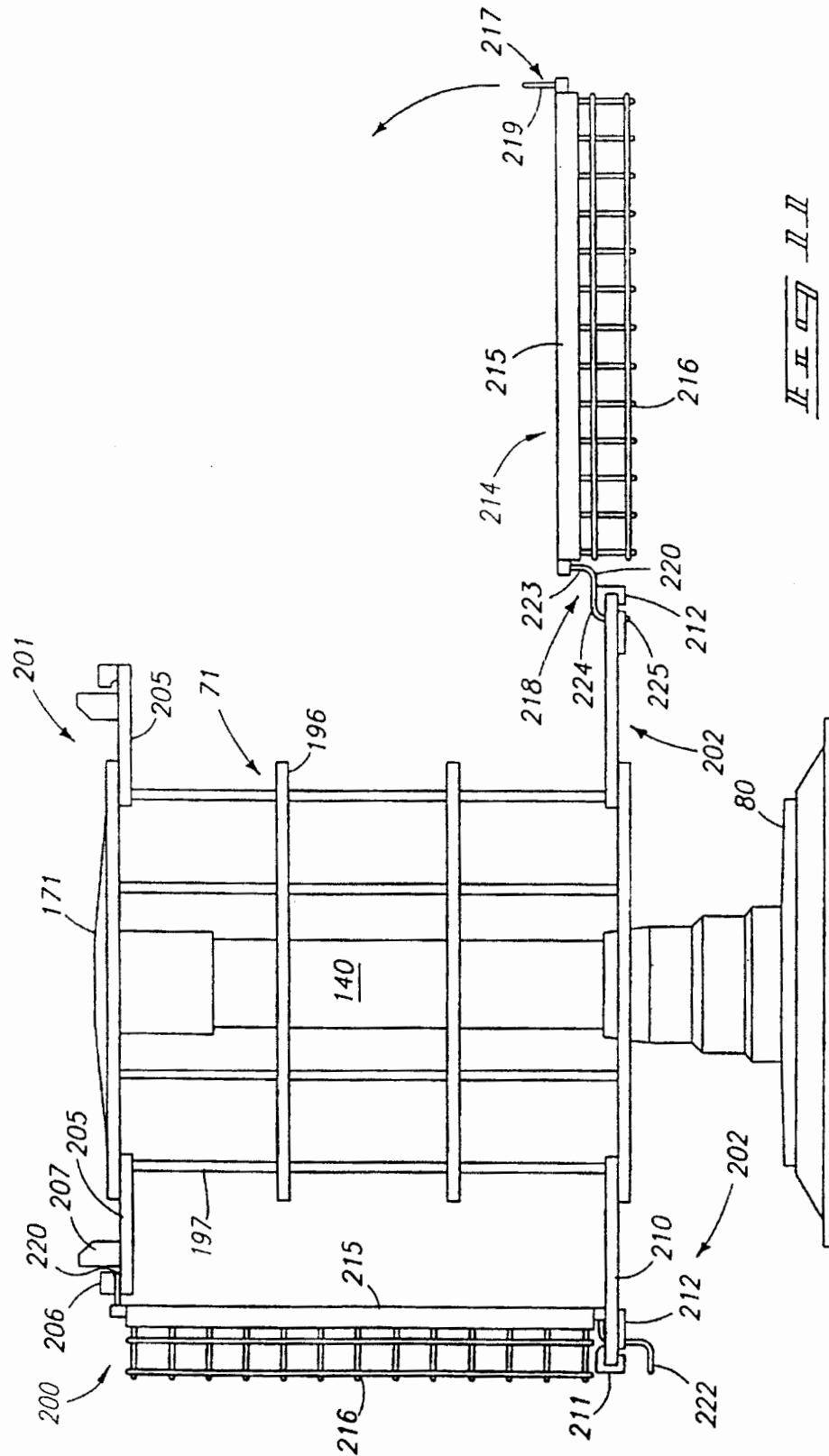
FIG. 10

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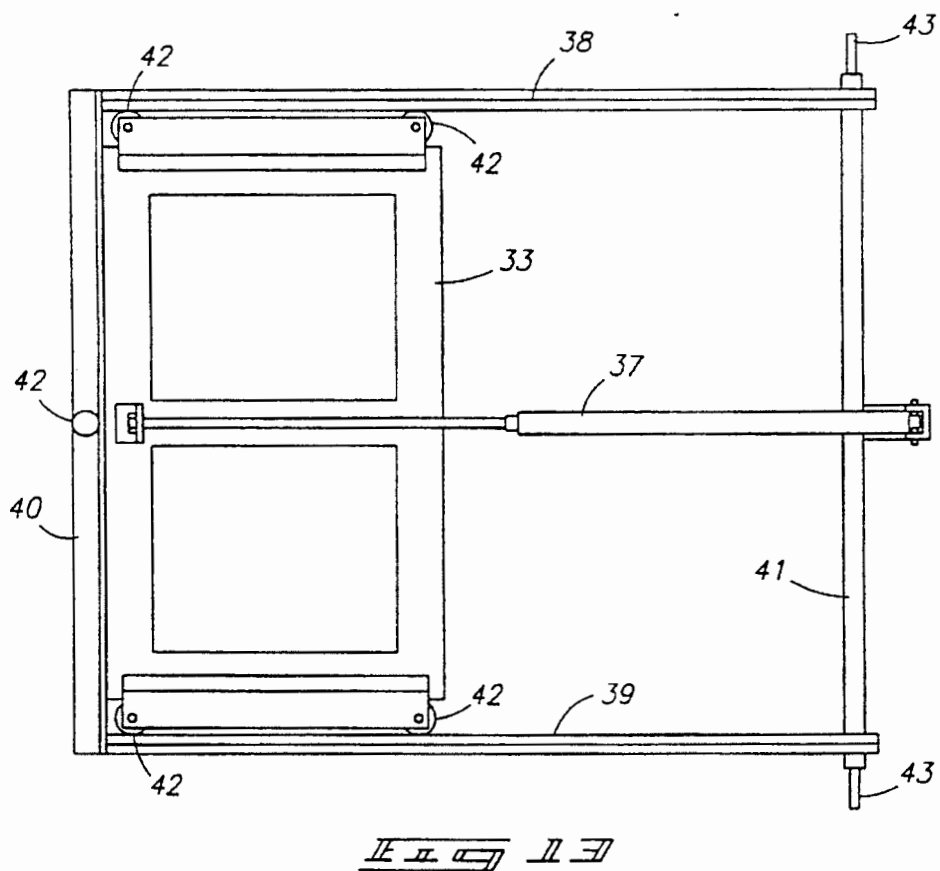
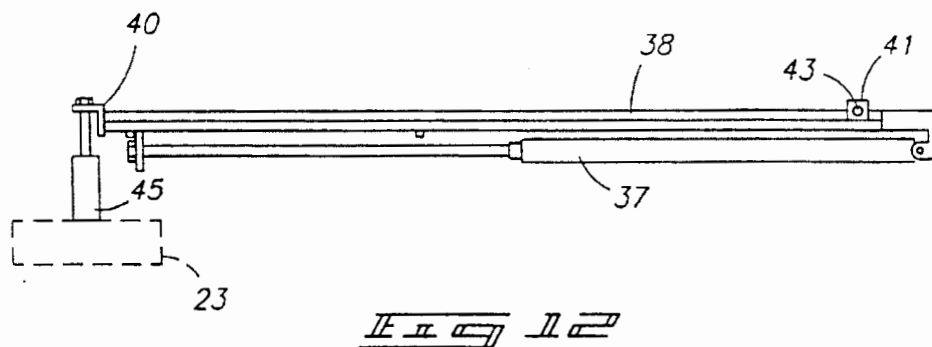


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## METHODS FOR CENTRIFUGALLY CLEANING WAFER CARRIERS

### CROSS-REFERENCES TO RELATED CASES

This is a divisional of U.S. patent application Ser. No. 08/727,271, filed Oct. 8, 1996, now U.S. Pat. No. 5,738,128 which was a continuation of U.S. patent application Ser. No. 08/360,724, filed Feb. 21, 1995 (U.S. Pat. No. 5,562,113), which was a national stage application based upon and claiming the filing date of Patent Cooperation Treaty Application Serial No. PCT/US93/05329, filed Jun. 3, 1993. U.S. patent application Ser. No. 08/360,724 was also a continuation of U.S. patent application Ser. No. 07/901,614, filed Jun. 15, 1992 (U.S. Pat. No. 5,224,503). Priority upon such applications is hereby claimed.

### TECHNICAL FIELD

The technical field of this invention is cleaning apparatus for rinsing and drying carriers used to hold and process semiconductor wafers, substrates, flat panel displays and similar articles requiring extremely low contamination levels.

### BACKGROUND ART

The processing of semiconductor wafers and substrates is very sensitive to problems of contamination. This is also true with photomasks, flat panel displays, data disks, and other articles relating to the semiconductor industry. These articles require extremely low contamination levels. Even minute contaminants can cause defects to occur in the processing of these low-contamination wafer articles. Accordingly, it is necessary to maintain a high level of cleanliness during all or nearly all stages of production.

Semiconductor wafers, substrates, photomasks, flat panel displays and other similar low-contamination wafer products are also typically processed in batches. Batch handling may occur throughout the entire production process, or for one or more processing steps or related handling operations. Batch processing of this type almost always utilizes some type of carrier or carriers to hold the thin wafer-like materials being processed.

In the batch processing of semiconductor substrates and wafers, a wafer carrier is used to hold a group of these articles. The wafer carriers can be of various designs and are more specifically referred to as a wafer boat. In many applications the wafer boat is made of a suitable polymeric material, e.g. polypropylene or TEFLON® fluoropolymer. The sides and sometimes the bottom of the wafer boat have receiving slots formed to receive and positionally restrain the wafers in a spaced array with the faces of the wafers adjacent one another. Typically, the central axes of the wafers are aligned. The wafers are slid into the boat, such as from the side or above and removed by sliding them outwardly. The receiving slots in the wafer boat are shallow so that the wafer is engaged only at the peripheral edges and along a thin marginal band extending inwardly from the periphery.

Wafer carriers can also be provided in the form of a protective case or box in which the wafers are held and enclosed against contamination during travel within the processing facility. Wafer carriers of this type are frequently designed to hold a wafer boat having a complementary design. The complementary relationship of the protective wafer carrier box and the wafer carrier boat allow the boat and supported wafers to be fully enclosed and positionally restrained in all directions during transport.

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The manufacture of wafer carriers also includes their cleaning. Cleaning of wafer carrying boxes and wafer carrying boats is difficult because they typically have features which include slots, grooves or apertures which are difficult to fully clean. This is greatly exacerbated by the extremely low contamination levels which can be accepted for articles used directly or indirectly in processing of the wafer articles. Dust, metal particles, oils and other organic chemicals may be present on the surfaces of the molds or other production tools used to make wafer carriers. Fully cleaning the wafer carriers to the required extremely low contamination levels is also difficult. Cleaning the wafer carriers for use in semiconductor processing is a task which in some cases is almost as difficult as mechanically forming the article.

The cleaning of wafer carriers has until this invention remained a difficult and relatively costly procedure. The current invention has several advantages and benefits which are explained or otherwise indicated herein.

### BRIEF DESCRIPTION OF THE DRAWINGS

One or more preferred forms of the invention are described herein with reference to the accompanying drawings. The drawings are briefly described below.

FIG. 1 is a front elevational view of a preferred embodiment of cleaning apparatus according to the current invention.

FIG. 2 is a rear elevation view of the apparatus shown in FIG. 1.

FIG. 3 is a left side elevational view of the apparatus shown in FIG. 1.

FIG. 4 is a right side elevational view of the apparatus shown in FIG. 1.

FIG. 5 is a top view of the apparatus shown in FIG. 1.

FIG. 6 is a rear elevational view of the apparatus shown in FIG. 1 with portions removed for purposes of illustration.

FIG. 7 is an additional rear elevational view of the apparatus shown in FIG. 1 with further portions removed for purposes of illustration.

FIG. 8 is a longitudinal sectional view of selected portions of the apparatus of FIG. 1 showing the rotor and drive construction.

FIG. 8A is a longitudinal sectional view showing a portion of FIG. 8 in greater detail.

FIG. 8B is a longitudinal sectional view showing a portion of FIG. 8 in greater detail.

FIG. 9 is a cross sectional view taken along line 9—9 of FIG. 7.

FIG. 10 is a top view of the rotor shown in isolation.

FIG. 11 is a side view illustrating a preferred wafer carrier support construction used in the apparatus of FIG. 1 shown in isolation with the rotor assembly.

FIG. 12 is a detail top view showing in isolation a preferred door construction used in the apparatus of FIG. 1.

FIG. 13 is a detail front view showing in isolation the preferred door construction of FIG. 12.

### BEST MODES FOR CARRYING OUT THE INVENTION AND DISCLOSURE OF INVENTION

FIG. 1 shows a preferred centrifugal wafer carrier cleaning apparatus 20 according to this invention. Apparatus 20 includes a processing bowl or vessel 21 and a frame 22. Frame 22 has a number of frame members 23 which run both



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vertically and horizontally and are joined together to form an assembly which acts as the structural framework of apparatus 20. External finish panels 24 are detachably mounted between the frame members using suitable fasteners. As shown the finish panels are adapted for convenient detachment and reinstallation using a panel mounting system. The panel mounting system advantageously includes panel latch assemblies which utilize latch activators 25 to controllably latch and unlatch the finish panels. The latch activators 25 are connected mechanically to latch pins (not shown) which engage with the frame members 23 at suitable locations. The finish panels can be temporarily removed to allow maintenance upon internal components. The assembly of frame 22 and finish panels 24 in combination form the exterior or outer surfaces of cleaning apparatus 20.

As shown in FIGS. 1-3, a wafer cleaning apparatus 20 includes a front side 26, rear side 27, right side 28, left side 29, top side 30, and bottom side 31. Front side 26 has an associated entrance closure or first door 33 which is controllable to open and close a first opening or entrance port 34 formed in the sidewall of processing vessel or bowl 21. Rear side 27 has an associated exit closure or second door 35 which is controllable to open and close a second opening or exit port 35 which is also formed in the sidewall of processing bowl 21. FIGS. 1 and 2 show doors 33 and 35 in fully closed positions wherein the entrance and exit ports 34 and 36 are closed and substantially sealed shut to prevent fluid leakage.

FIG. 13 shows that doors 33 and 35 are preferably supported upon a door support structure having upper and lower guides 38 and 39. Guides 38 and 39 are advantageously connected to inner and outer vertical connection bars 41 and 40. The inner connection bar 41 has journal extensions 43 which are supported in bearing blocks 44 (see FIG. 6) mounted upon frame 22. The door support structures for doors 33 and 35 are mounted behind the adjacent central finishing panels 24a and 24b. The corners of doors 33 and 35 are provided with rollers 42 which roll upon the guides 38 and 39. Doors 33 and 35 are preferably operated relative to the door support structures by pneumatic rams 37. The door support structures and doors are pivoted inwardly to seal against the peripheral flange of the entrance and exit ports. This is done by controllably pivoting the door support structures using a door pivot actuator 45 which is advantageously a pneumatic ram extending between the outer vertical bar 40 and an adjacent frame member 23 (shown in phantom in FIG. 12).

The door is operated in the following manner. The pivot actuator 45 is maintained in an extended position until the door 33 has been fully extended toward the outer vertical bar 40. The pivot actuator is then operated to retract the door and support assembly formed by the door and door support structure. Conversely, when opening the door the pivot actuator is first extended to move the door and support assembly outwardly from the processing bowl 21. Thereafter the door is rolled upon the guides 38 and 39 and retracted toward the inner vertical bar 41.

The bottom 31 of apparatus 20 is advantageously provided with a set of casters 48 which are connected to the frame 22 near the bottom corners. The bottom corners of apparatus 20 are also preferably fitted with extendible and retractable stabilizers 49. The stabilizers have a fixed upper part 49a which is connected to the frame. A lower extendible part 49b is adjusted relative to the upper part. Apparatus 20 can thus be rolled to a suitable location. Thereafter the stabilizers can be extended to transfer the weight of the apparatus from casters 48 to the stabilizers and provide increased stability.

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FIG. 1 shows that the wafer carrier cleaning apparatus 20 includes three sections 51-53; herein termed the upper of first section 51, the middle or second section 52, and the lower or third section 53. The upper or first section 51 includes a primary drying gas treatment system. The primary drying gas treatment system includes a suitable primary drying gas filter 55 shown in FIG. 2. Filter 55 is received within the outer portions of the drying gas plenum 57. FIG. 6 shows that the preferred construction of the plenum includes a filter stop 67 which extends about the interior of the plenum adjacent to but spaced inwardly from the filter opening 58. The filter 55 is installed within the plenum and is in part retained by the filter stop 67. Two connection brackets 68 are advantageously included at the sides of filter opening 58 to assist in mounting a finishing panel which also serves to support the outer face of the filter and keep the filter in the installed position.

In a typical installation the exit or rear side 27 of the apparatus is within a clean room or similar low contamination environment. Air can be pulled from the clean room and through the filter 55. Filter 55 is preferably a HEPA type or other suitable filter capable of removing very small particulate matter with great effectiveness. Filter 55 is constructed with a relatively large surface area to minimize pressure drop associated with moving air or other drying gas therethrough. This is helpful in eliminating the need for a specific, dedicated drying air fan which would otherwise increase particulate contamination. Contamination could occur to the primary drying gas flow path if a specific, dedicated drying gas fan was included therein. Such a hypothetical construction could also lead to contamination to the interior processing chamber 47 of vessel 21. Primary drying gas passes through the processing chamber to remove moisture therefrom. A hypothetical fan and associated drive motor which is specifically functions to move primary drying air or other drying gas also generates significant amounts of general contamination within or adjacent to the wafer carrier cleaning apparatus. This general contamination outside the processing vessel 21 nonetheless causes particulate matter to enter the processing chamber and prevents the very low contamination levels needed in the processing of semiconductor and other low-contamination wafer products;

FIG. 6 shows that the upper section 51 of the wafer carrier cleaning apparatus also preferably includes a drying gas heater 56. Drying gas heater 56 is mounted within a primary drying gas plenum 57. Plenum 57 serves as a drying gas enclosure and conduit. Air or other drying gas is passed through filter 55. Filter 55 is mounted within a plenum intake opening 58 which is substantially the entire side of the plenum. Filtered air received within the plenum passes about heater 56. Air within the plenum also passes down through a central heater opening 61 which extends through the lower section 62 of the heater. Heater 56 also has an upper section 59 which is provided with a cover that encloses wiring connections and mounts for an array of spaced parallel electrical resistance heating elements 60 mounted within the lower section of the heater and across the central opening 61. Each heating element 60 is preferably provided with a multitude of fins to improve heat transfer to the air or other primary drying gas passed thereover.

Air passes down through the central heater opening 61 and from the plenum through a plenum exhaust opening 63 in the central bottom of the plenum. The plenum exhaust opening is open to a processing bowl top port 65 (FIG. 7). Opening 63 and top port 65 allow communication of filtered, heated drying gas from the plenum into the processing vessel at a position substantially is aligned with the central



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axis of the processing chamber and the rotational and longitudinal axis of rotor 70.

The primary drying gas plenum 57 is also preferably provided with a static electricity suppressor 66. Static suppressor 66 can be selected from suitable types of commercially known units. It preferably has exposed electrodes which are charged to desired electrical potentials to help neutralize static electricity generated by movement of drying gas through plenum 57 and over associated surfaces of the plenum and enclosed heater 56. The particular operating parameters used may vary dependent upon environmental and climatic conditions.

FIG. 6 shows that the middle or second section 52 includes the processing vessel or bowl 21. The processing bowl 21 is mounted upon the frame 22 using suitable fasteners (not shown). Processing bowl 21 is roughly cylindrical having semicircular sidewall sections 72. The sidewall of the processing bowl is completed by two substantially flat panels 73 on the opposing front and rear sides. The first or entrance flat sidewall panel includes the first or entrance port 34. The exit or second flat sidewall panel includes the second or exit port 36. Both the entrance and exit ports are preferably built with port flanges 74 which are relatively thicker than the sidewall panels 73 to strengthen the vessel and provide surfaces against which the doors 33 and 35 can seal. FIG. 6 has been simplified by not showing the rotor assembly 70 through the port 74. The details of the rotor and other internals of the processing bowl are described in connection with FIG. 7.

FIG. 7 shows that the processing bowl also has a top wall 76. The top wall is most preferably a relatively low flat frustoconical shape. The top wall has the top port 65 which serves as a primary drying gas supply formed therethrough. Port 65 thus provides an inlet to primary drying gas flowing from the plenum 57 into the processing chamber 47.

The processing bowl also has a bottom wall which is of composite construction. FIG. 8 illustrates specifics of the preferred construction. The first part of the bottom wall is an outer bottom wall piece 77 which is annular and connects to the lower edges of the processing bowl sidewall sections 72 and 73. The central portion of the bottom wall is open to provide a construction which accommodates inherent vibration of the rotating assembly and associated drive which will be described in greater detail hereinafter. This construction utilizes a flexible membrane or diaphragm 78 which is annular and extends inwardly from the inner edge of an annular outer bottom wall piece 77. The outer edge of the annular diaphragm 78 is captured between the outer bottom wall piece 77 and an outer diaphragm retaining ring 79 which is connected thereto using suitable fasteners. The inner edge of diaphragm 78 is raised relative to the outer edge, and is connected to a drive mount base plate 80. A diaphragm inner edge retaining ring 81 is connected by fasteners below the base plate 80 to capture diaphragm 78 therebetween.

The processing chamber 47 is also most preferably provided with a false bottom or bottom baffle 85. The bottom baffle is sized to provide a space between its outer periphery and the inside surfaces of the processing bowl sidewalls. This annular exhaust and drain baffle space allows exhausting gas and draining liquids to flow across and down about the outside of the baffle. Bottom baffle 85 is most preferably constructed using two baffle parts, an upper or first baffle part 86, and a lower or second baffle part 87. The upper baffle part is flat, or more preferably, slightly crowned to drain liquids which fall thereon. The lower baffle part 87 is

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frustoconical expanding upwardly to connect with and support the peripheral edge of the upper baffle part 86. The bottom baffle assembly 85 is supported upon baffle mounting brackets 88 which extend upwardly from the outer bottom wall 77 to connect with the lower baffle part 87.

The processing vessel 21 is preferably fitted with at least one outer spray manifold 90. Outer spray manifolds 90 are connected directly to the sidewalls 72. External spray manifold supply fittings 91 connect with liquid supply conduits 92. As shown, processing chamber is advantageously provided with four (4) outer spray manifolds 90 at spaced approximately equiangular points about the central axis of the processing chamber. The outer spray manifolds are provided with a plurality of liquid spray nozzles 93. Spray nozzles 93 are directed inwardly to spray water, water and detergent, solvents, mixtures thereof, or other cleaning liquids generally inward or directly toward the central axis of the processing chamber.

FIG. 7 shows that the processing vessel 21 is also preferably fitted with at least one outer drying gas manifold 100. Outer drying gas manifolds 100 are similar to outer cleaning liquid spray manifolds 90 in basic construction and mounting to the processing vessel sidewall 72. The outer drying gas manifolds are supplied with a suitable pressurized secondary drying gas through supply fittings 101 mounted in the sidewall 72. The supply fittings 101 (see FIG. 6) are connected to secondary drying gas supply conduits 102. These conduits are supplied with a suitable secondary drying gas, such as clean dry air or nitrogen. The drying gas manifolds have gas nozzles or jets 103. Jets 103 are inwardly directed to provide streams of secondary drying gas which impinge upon the wafer carriers being dried. As shown, there are four (4) outer secondary drying gas manifolds 100 which are spaced approximately equiangularly about the processing chamber. The gas manifolds and spray manifolds are advantageously arranged in alternating sequence about the diameter of the circular outer manifold array formed by manifolds 90 and 100.

FIGS. 7 and 9 also indicate that processing chamber 47 is preferably provided with a number of inner liquid spray manifolds 110 and inner secondary drying gas manifolds 120. The function of manifolds 110 is to spray cleaning and rinsing liquid(s) at wafer carriers mounted upon the rotor 70. The inner spray manifolds are mounted in a circular array at approximately equiangularly spaced positions, as shown in FIG. 9. The inner liquid spray manifolds are mounted to the bottom baffle 85 and extend upwardly at radial positions which are within the cage 71 of rotor 70. The wafer carriers being cleaned and dried are mounted upon the rotor cage 71, in a suitable manner, such as indicated below. The inner liquid spray manifolds 110 are provided with a plurality of nozzles 113 mounted upon the manifolds at spaced vertical locations. The nozzles are directed in a generally outward or radial direction toward the rotor cage.

FIG. 9 shows an array of inner secondary drying gas manifolds 120 interpositioned in an alternating pattern with the inner liquid spray manifolds 110. As shown there are four (4) manifolds 120 which are approximately equiangularly arranged about the central axis of the processing chamber and the rotational axis of rotor 70. Manifolds 120 have a plurality of vertically spaced nozzles or jets 123 arranged along the upstanding manifolds. The jets direct diverging streams of secondary drying gas in a generally outward direction toward the rotor cage 71 and against wafer carriers supported thereon. The drying gas is used to blow and evaporate any rinsing or washing liquids from the surfaces of the rotor and supported wafer carriers being cleaned.

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Liquid supplied to spray manifolds 90 and 110 and secondary drying gas supplied to manifolds 100 and 120 are preferably controlled by an automatic controller (not shown) which operates electrical solenoid valves (not shown). The electrical solenoid valves control the flow of compressed air or other pneumatic control gas or other suitable fluid. The control gas is controllably delivered to pneumatically controlled solenoid valves which directly control the flow of cleaning liquids and drying gas to the manifolds 90 and 100. Manual cleaning fluid supply valves (not shown) and manual secondary drying gas valves (not shown) are also connected in parallel with the pneumatically controlled valves to allow manual operation if desired.

Pressure gauges 95 (see FIG. 4) are advantageously used to provide an indication of the pressures to the spray and gas manifolds. Associated pressure regulator valves 96 are also included to allow manual regulation of the delivery pressures to the manifolds.

The processing vessel 21 is also provided with a suitable means for draining liquids therefrom. It is further provided with a suitable means for exhausting the drying gases. As shown, wafer carrier cleaning apparatus 20 includes a liquid drain and gas exhaust subsystem 130 which in part combines these functions. The drain and exhaust subsystem 130 includes an outflow box 131. Outflow box 131 is mounted beneath the bottom wall of the processing bowl 57. The outer bottom wall piece 77 has a processing chamber outflow opening or port formed therethrough adjacent to the outflow box. Liquids drain across the bottom wall of the processing bowl and into the outflow box. Gases flow from the processing chamber through the outflow port and into the outflow box 131. The bottom of the outflow box is sloped toward a central trough and a liquid outflow drain opening 134. A liquid drain line or conduit 133 extends from the drain opening 134 and carries liquids draining from the processing chamber to a suitable facilities drain pipe or sewer.

The outflow box 131 also has a gas exhaust port 135 which passes exhausting gases from the outflow box into a suitable gas exhaust conduit. As shown in FIGS. 1-5, the gas exhaust conduit is in the form of an upstanding exhaust gas stack 136. As shown in FIG. 5, the exhaust stack 136 on the top surface 30 of the apparatus 20 is connected to a suitable facilities exhaust system to remove the gas and contained liquid vapors removed from the processing chamber.

FIG. 7 shows portions of a rotating assembly which includes the rotor 70 with attached rotor cage 71. The rotor is supported in an upright position by a rotor housing 140. Rotor housing 140 is mounted upon base plate 80. Base plate 80 is supported upon frame drive assembly mounting members 23a which extend in a generally front-to-back orientation. Members 23a are a weldment subframe which attaches to the frame 22. This is advantageously accomplished using a drive assembly mounting ring 82 which is bolted to members 23a. Elastic mounting bushings 83 are interpositioned between the base plate and mounting ring 82 to accommodate vibration and shock. Fasteners 84 extend through apertures in fastener caps 89, ring 82, bushings 83 and base plate 80, to secure the base plate to the frame in a manner suitable for dissipating vibration and shock.

A drive motor 150 is mounted beneath the base plate 80 to drive the rotating assembly. Motor 150 extends downwardly into the lower or third section 53 of the wafer carrier cleaning apparatus. Motor 150 is preferably a brushless direct current type electrical motor to prevent particulate contamination associated with contacting electrical brush

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type motors. The motor is positioned by complementary tapered alignment rings 190.

FIGS. 8, 8a and 8b show in sectional view the rotor, rotor housing, and drive components in greater detail. Rotor 70 includes a rotor shaft 144. Rotor shaft 144 is mounted for rotation within the rotor housing 140. The rotor housing includes an upper or first housing piece 141 and a lower or second housing piece 142. The first and second housing pieces are connected by a series of fasteners 143. The rotor housing 140 is connected to the base plate 80 using fasteners 145. The lower second rotor housing also functions as a housing which encloses a brake assembly 155.

FIGS. 8 and 8A show that rotor 70 is mounted for rotation within the upper rotor housing 141 using an upper or first bearing 147 and a lower or second bearing 148. The upper bearing is advantageously a double ball bearing with the outer race of the bearing positioned within an upper rotor bearing mounting sleeve 157. The mounting sleeve 157 is held by fasteners 160 to the upper, distal end of rotor support housing piece 141. Mounting sleeve 157 also holds bearing seals 161 and 162 which seal the bearing area to retain lubricant and prevent migration of particulates generated by the bearings. The first upper rotor bearing seal 161 is captured in position between the outer race of bearing 147 and a retainer ring 165 held by fasteners 160. A shield 164 is also advantageously included to protect seal 161. The second upper rotor bearing seal 162 is held in position using two spring retainer rings 163 on both sides thereof. A suitable shield 164 is also advantageously used.

FIG. 8A also shows that the upper distal end of rotor shaft 144 is preferably provided with a flange 168 having mounting apertures which receive bolts 169. A splash shield or cap 170 is held between the rotor wheel 171 and flange 168 using bolts 169. The shield cap 170 and rotor wheel 171 rotate with shaft 144.

FIGS. 8 and 8B show the lower rotor bearing mounting arrangement and adjacent components. Lower bearing 148 is of a type suitable to support most of the thrust loading caused by the weight of the rotating assembly. Spherical contact self-aligning ball bearings are suitable. The inner rotating race of bearing 148 is held in position upon shaft 144 using spring ring retainers 173. A bearing shield 174 is held in position above bearing 148. The outer race of bearing 148 is held within a lower rotor bearing mounting sleeve 176. Mounting sleeve 176 is connected to the lower or proximate end of rotor housing piece 141 using fasteners 177. Mounting sleeve 176 also mounts a shaft seal 178 using a spring retainer ring 179.

The drive assembly also preferably includes a rotating assembly brake 155. The brake assembly 155 is enclosed within the lower or second rotor housing piece 142. The brake includes a rotating cylindrical brake part 181 which is secured to the rotor shaft 144 and motor output shaft 151 using a key 182 and two opposing spring retainer rings 187. The outer periphery of the rotating cylindrical brake part 181 is contacted by a series of brake contact pads 183. The brake contact pads 183 line the interior face of a cylindrical annulus which serves as a brake actuator 184. Brake actuator 184 is elastically deformable and is inflated by supplying pressurized fluid to the internal expansion chamber 185. When inflated the contact pads are moved inwardly to rub against the outer face of the rotating brake part or drum 181. The rotating assembly can be controllably stopped using the brake system 155. This is important in slowing the rotating assembly and in stopping the rotating assembly in a suitable position for loading and unloading wafer carriers. The



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rotating assembly is freed to rotate by relieving the pressure within chamber 185.

The rotating assembly also includes a rotor wheel 171 which is mounted to the upper distal end of the upstanding rotor shaft 144. Rotor wheel 171 has a peripheral ring 192 which is connected to a hub 194 using a plurality of spokes 193. The spaces between the spokes are open to facilitate a downward flow of primary drying gas from the primary drying gas inlet port 65 into the space within the interior of rotor cage 71.

The rotor wheel supports the rotor cage 71. The rotor cage includes a number of peripheral rings 196. The uppermost peripheral cage ring is advantageously formed by peripheral ring 192 of rotor wheel 171. The cage also includes a number of longitudinal connection bars 197 which extend between the cage rings 196. Reinforcement pieces 198 connect between the rotor wheel and cage to add strength and they also provide addition blade area for moving drying gas as the rotor turns.

The rotary motion of the rotor wheel and rotor cage cause centrifugal action of the drying gas and thereby induces a flow of gas. The flow of drying gas is generally downward into the interior of the rotor cage, and then outward toward the peripheral sidewalls of the processing vessel. The bottom baffle 85 is spaced inwardly from the processing vessel said walls leaving an annular flow space thereabout. The centrifugal action of the rotor thus induces an outward flow which proceeds outwardly and downwardly to form a downwash which exits through the annular opening about the bottom baffle. Beneath the bottom baffle the gas flow proceeds across the bottom wall of the processing vessel toward the drain and exhaust box 131. This construction maintains a relatively controlled drying gas flow path which carries liquid vapors from the processing chamber and minimizes turbulence and complex gas flows near the bottom of the chamber which otherwise will occur and derogate the particle counts exhibited by the wafer carriers processed through the cleaning apparatus 20.

FIGS. 9-11 show a preferred construction providing wafer carrier supports 200 which hold wafer carriers in position for cleaning within apparatus 20. As shown there are four (4) wafer carrier supports 200 at spaced, approximately equiangular positions about rotor cage 71. The wafer carrier supports include an upper or first mounting bracket 201 and a lower or second mounting bracket 202. The mounting brackets are secured to the rotor cage rings 196 using suitable fasteners 203. The upper wafer carrier mounting brackets include a main bracket piece 205. Connected thereto are an outer retaining lug 206 and an inner stop piece 207, both of which are advantageously made of nylon or other suitable polymer material. The lower mounting brackets 202 include a main bracket piece 210 which mounts an outer roll bar 211 and an inner rest piece 212.

The wafer carrier supports further include a detachable wafer carrier support basket 214. Wafer carrier support baskets 214 have a perimetric frame 215 and a reticulated basket 216. The baskets have an opening defined by the perimetric frame with the basket extending outwardly to form a wafer carrier storage space therewithin. The wafer carriers are held along the inwardly directed side of the basket 216.

The wafer carrier supports are provided with bracket engaging ends 217 and 218. The first or upper bracket engagement end 217 is adapted to engage with the upper or first mounting bracket 201. The second or lower bracket engagement end 218 is adapted to engage with the lower or

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second mounting bracket 202. First bracket engagement end 217 has a first end engagement loop 219 which extends approximately perpendicular to the plane defined by the perimetric frame 215. Loop 219 is directed from the basket opening, or upwardly when the basket is laid flat and inwardly when installed upon the rotor. Loop 219 is lifted up and over outer retainer lug 206 and then lowered into the position shown at the left in FIG. 11. A retaining groove 220 is formed in the inward face of lug 206 in order to receive and retain the loop in position. Centrifugal action forces the loop into groove 220.

The second or lower bracket engagement end 218 has a loop 222 which extends is curved to form three different sections. The first section 223 is perpendicular to the plane of the basket opening. This first section extends in a direction along the end of the basket and opposite to the direction of the first loop 219. The second section 224 of loop 222 extends parallel to the plane of the basket opening and away from the basket. The first and second sections are joined in a curve which bears upon a curved outer-upper corner of the lower bracket rest or support piece 212. Loop 222 also has a third section which extends and is oriented similar to the first section 223. The second and third sections are joined by a curve which bears upon and rolls over the outer roll bar 211 as the basket is installed. The basket pictured at the right in FIG. 11 shows the starting position. The basket is then pivoted or rolled upwardly and lifted to allow the loop 219 to clear over the lug 206. The basket is then lowered or dropped into the installed position shown at the left in FIG. 11.

The wafer carrier cleaning apparatus is used to perform a wafer carrier cleaning process. The wafer carrier cleaning process begins by loading the wafer carriers into baskets 216. The entrance door 33 is then opened and the loaded baskets are installed upon the rotor through the entrance port 34. This is repeated until all wafer carrier supports have been loaded, preferably with loads having about the same weight. The operation then involves closing the entrance door using the actuating ram 38. The closing also involves sealing and the entrance door to the entrance port 34.

Thereafter the wafer carriers are subjected to a cleaning process which includes rotating the rotor and spraying the wafer carriers with water, solvent, detergent or other washing and cleaning liquid(s) supplied through the inner and outer liquid spray manifolds 110 and 90. The cleaning using liquid spraying and rotating steps is performed for sufficient time to adequately cleanse all surfaces of the wafer carriers being cleaned. The simultaneous spraying and rotating serves to direct the sprays of liquid from differing directions to enhance solubilization of dirt, grease and other contaminants which may be present upon the wafer carriers prior to cleaning.

After treating the wafer carriers with the cleaning liquids, a drying process is advantageously performed. The drying process includes supplying the drying gases to the processing chamber. The primary drying gas is supplied through plenum 57. This primary drying gas is treated by filtering the incoming air or other primary drying gas. Then the primary drying gas is treated by heating it to a desired temperature, such as in the range of 100° F. to 300° F., or higher dependent upon the materials from which the wafer carriers are constructed. The primary drying gas is also treated by dissipating static electricity using the static suppressor 66. The filter, heated, and static electricity dissipated primary drying gas is then used by supplying it to the processing chamber 47. The flow of primary drying gas is developed by inducing the flow by rotating the rotor. The centrifugal

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action of the rotor thus sucks primary drying gas through the filter, plenum and heater and into and through the processing chamber. The induced flow of primary drying gas performs a drying function upon the wafer carriers being rotated within the processing chamber.

The wafer carriers are also preferably subjected to drying by supplying pressurized secondary drying gas to the outer and inner drying gas manifolds 100 and 120. The drying operation is enhanced by streaming or jetting the drying gases toward the wafer carriers while rotating the wafer carriers loaded upon the rotor. This simultaneous rotating and jetting with drying gas helps to expose the interstices of the wafer carriers to the drying action of the secondary drying gas as well as the primary drying gas. The secondary drying gas can be clean dry air, nitrogen or other suitable drying gas supplies having low contamination and low vapor content thus enhancing the rate of drying and speeding the overall processing rate. The wafer carriers are subjected to both primary and secondary drying for sufficient time to effectuate a dry condition on all surfaces of the wafer carriers.

The wafer carriers are further processed by stopping the rotor and incrementally positioning the wafer carrier supports 200 adjacent to the exit port 36. After the first wafer carrier support is positioned adjacent to exit port 36, the process includes opening exit door 35 using door operator 37. The wafer carrier support is then removed from the rotor by lifting the upper loop 219 clear of lug 206 and pivoting the wafer carrier support downwardly into the loading position shown in FIG. 11 at the right. The wafer carriers can then either be removed from the basket or the entire wafer carrier support can be removed and unloaded elsewhere as deemed best.

It is further noteworthy that the wafer carriers are loaded from a relatively less clean room, sometimes called a "grey room". The cleansed units are unloaded into a clean room having very low propensity for contaminating the cleaned wafer carriers. Thus the wafer carrier cleaning apparatus is preferably installed so that the entrance door operates in the grey room environment and the exit door operates in the clean room environment.

The wafer carrier cleaning apparatus is constructed using known welding, machining and other forming operations to provide the components and assemblies described in detail hereinabove. The processing chamber bowl and other conduits which supply gas or liquids are preferably made of stainless steel. Structural components can be made of steel or other suitable materials.

#### Industrial Applicability

The invention is useful for cleaning wafer carriers, boxes for holding wafer carriers, and analogous articles requiring very low contaminant levels.

What is claimed is:

1. A process for cleaning carriers used to hold semiconductor articles comprising the steps of:

loading at least one corner upon a rotor within a processing chamber;

rotating the rotor with the at least one carrier supported thereon;

spraying cleaning liquid upon the at least one carrier, said spraying occurring during at least a portion of said rotating;

flowing primary drying gas in a generally downwardly direction through the processing chamber; and

jetting secondary drying gas upon the at least one carrier.

2. A process according to claim 1 wherein said jetting occurs during at least a portion of said rotating.

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3. A process according to claim 1 wherein said flowing primary drying gas is performed with primary drying gas entering upper portions of the processing chamber.

4. The process of claim 1 further comprising the step of flowing the primary drying gas into an interior space of the rotor.

5. The process of claim 1 further comprising the step of flowing the primary drying gas outwardly toward sidewalls of the processing chamber.

6. The process of claim 1 further comprising the step of jetting the secondary drying gas outwardly through the rotor.

7. The process of claim 1 further comprising the step of heating the primary drying gas.

8. The process of claim 1 further comprising the step of jetting the secondary drying gas inwardly toward the wafer carriers.

9. The process of claim 1 wherein the primary drying gas comprises clean dry air and the secondary drying gas comprises Nitrogen.

10. The process of claim 1 wherein the primary drying gas is induced to flow by rotating the rotor.

11. The process of claim 1 further including the step of removing moisture from the processing chamber by flowing primary drying gas through the processing chamber.

12. A process for cleaning carriers used to hold semiconductor articles, comprising:

loading carriers upon a rotor which is positioned within a processing chamber;

rotating the rotor with the carriers supported thereon;

spraying cleaning liquid upon the carriers, said spraying occurring during at least a portion of said rotating;

supplying primary drying gas to the processing chamber; and

jetting secondary drying gas upon the carriers;

wherein said supplying primary drying gas is accomplished through a primary drying gas port which is adjacent a rotational axis of the rotor.

13. A process for cleaning carriers used to hold semiconductor articles, comprising:

loading carriers onto a carrier support basket;

moving the carrier support basket into a processing chamber of a cleaning machine;

attaching the carrier support basket onto a first mounting bracket on a rotor in the processing chamber;

rotating the rotor and carriers supported thereon;

spraying cleaning liquid upon the carriers during at least a portion of said rotating; and

supplying drying gas to the processing chamber.

14. A process according to claim 13 wherein said spraying cleaning liquid upon the carriers is accomplished by supplying cleaning liquid from both inner and outer liquid supplies.

15. A process according to claim 13 wherein said supplying drying gas includes supplying primary drying gas to the processing chamber and jetting secondary drying gas upon the carriers.

16. A process for cleaning carriers used to hold semiconductor articles, comprising:

loading carriers upon at least one carrier support;

loading said at least one carrier support upon a rotor which is positioned within a processing chamber;

rotating the rotor and carriers supported thereon;

spraying cleaning liquid upon the carriers, said spraying occurring during at least a portion of said rotating; and



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supplying drying gas to the processing chamber;  
wherein said carriers are loaded upon plural carrier supports.

17. A process for cleaning carriers used to hold semiconductor articles, comprising:

loading carriers upon at least one carrier support;

loading said at least one carrier support upon a rotor which is positioned within a processing chamber;

rotating the rotor and carriers supported thereon;

spraying cleaning liquid upon the carriers, said spraying occurring during at least a portion of said rotating; and

supplying drying gas to the processing chamber;  
wherein said loading carriers includes loading the carriers onto at least one carrier support which includes a support basket which is detachable from the rotor.

18. A process for cleaning carriers used to hold semiconductor articles, comprising:

loading carriers upon at least one carrier support;

loading said at least one carrier support upon a rotor which is positioned within a processing chamber;

rotating the rotor and carriers supported thereon;

spraying cleaning liquid upon the carriers, said spraying occurring during at least a portion of said rotating; and

supplying drying gas to the processing chamber;

wherein said supplying drying gas includes inducing flow of primary drying gas using said rotor.

19. A process for cleaning carriers used to hold semiconductor articles, comprising:

loading carriers upon at least one carrier support;

loading said at least one carrier support upon a rotor which is positioned within a processing chamber;

rotating the rotor and carriers supported thereon;

spraying cleaning liquid upon the carriers, said spraying occurring during at least a portion of said rotating; and

supplying drying gas to the processing chamber;

wherein said supplying drying gas includes supplying primary drying gas to the processing chamber and jetting secondary drying gas upon the carriers from both inner and outer drying gas supplies.

20. A process for cleaning carriers used to hold semiconductor articles, comprising:

loading carriers through an entrance port onto a rotor positioned within a processing chamber;

closing an entrance port door after said loading;

rotating the rotor and carriers supported thereon;

spraying cleaning liquid upon the carriers, said spraying occurring during at least a portion of said rotating;

supplying drying gas to the processing chamber;

unloading carriers through an exit port different from said entrance port.

21. A process according to claim 20 further comprising: opening an exit port door prior to said unloading.

22. A process according to claim 20 wherein said spraying cleaning liquid upon the carriers is accomplished by supplying cleaning liquid from both inner and outer liquid supplies.

23. A process according to claim 20 wherein said supplying drying gas includes supplying primary drying gas to the processing chamber and jetting secondary drying gas upon the carriers.

24. A process according to claim 20 wherein said supplying drying gas includes supplying primary drying gas to the processing chamber and jetting secondary drying gas upon the carriers from both inner and outer drying gas supplies.

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25. A process according to claim 20 wherein said supplying drying gas is performed with primary drying gas entering upper portions of the processing chamber.

26. A process according to claim 20 wherein said supplying drying gas includes inducing flow of primary drying gas using said rotor.

27. A process according to claim 20 wherein said supplying drying gas is accomplished by supplying primary drying gas through a primary drying gas port which is adjacent a rotational axis of the rotor.

28. A process for cleaning carriers used to hold semiconductor articles, comprising:

loading carriers through at least one port formed in a sidewall of a processing vessel, said carriers being loaded onto at least one carrier support connected to a rotor which is positioned within a processing chamber within the processing vessel;

rotating the rotor and carriers supported thereon;

spraying cleaning liquid upon the carriers, said spraying occurring from at least one outer supply which directs the cleaning liquid against the carriers from positions outward from the at least one carrier support during at least a portion of said rotating, said spraying also occurring from at least one inner supply which directs cleaning liquid against the carriers from positions inward of the at least one carrier support during at least a portion of said rotating; and

supplying drying gas to the processing chamber.

29. A process according to claim 28 wherein said carriers are loaded upon plural carrier supports.

30. A process according to claim 28 wherein said loading carriers includes loading the carriers onto at least one carrier support which includes a support basket which is detachable from the rotor.

31. A process according to claim 28 wherein said loading carriers includes loading the carriers upon plural carrier supports, the carrier supports including a support basket which is detachable from the rotor.

32. A process according to claim 28 wherein said supplying drying gas includes inducing flow of primary drying gas using said rotor.

33. A process according to claim 28 wherein said spraying cleaning liquid upon the carriers is accomplished by supplying cleaning liquid from both inner and outer liquid supplies.

34. A process according to claim 28 wherein said supplying drying gas includes supplying primary drying gas to the processing chamber and jetting secondary drying gas upon the carriers.

35. A process according to claim 28 wherein said supplying drying gas includes supplying primary drying gas to the processing chamber and jetting secondary drying gas upon the carriers from both inner and outer drying gas supplies.

36. A process according to claim 28 wherein said supplying drying gas is performed with primary drying gas entering upper portions of the processing chamber.

37. A process according to claim 28 wherein said supplying drying gas includes inducing flow of primary drying gas using said rotor.

38. A process according to claim 28 wherein said supplying drying gas is accomplished by supplying primary drying gas through a primary drying gas port which is adjacent a rotational axis of the rotor.

\* \* \* \* \*

**Exhibit C**

ORIGINAL

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15 Attorneys for Plaintiff Semitool, Inc.

16 UNITED STATES DISTRICT COURT  
17 NORTHERN DISTRICT OF CALIFORNIA  
18 SAN FRANCISCO DIVISION

19 SEMITOOL, INC., a Montana corporation,

20 Plaintiff,

21 v.

22 DYNAMIC MICRO SYSTEMS  
23 SEMICONDUCTOR EQUIPMENT GmbH,  
24 a German corporation,

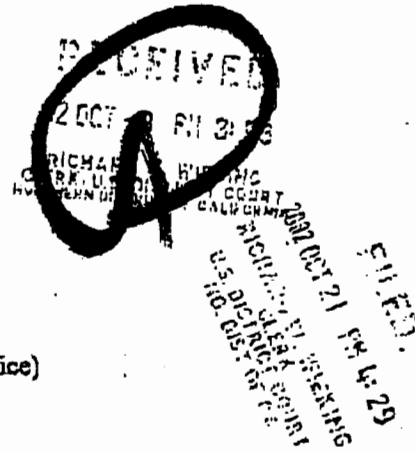
25 Defendant.

CASE NO. C01-1391 WHA

STIPULATION AND ORDER  
GRANTING PERMANENT  
INJUNCTION

26 Plaintiff Semitool, Inc. ("Semitool") and defendant Dynamic Micro Systems  
27 Semiconductor Equipment GmbH ("DMS") (collectively, the "Parties"), having entered  
28 into a confidential Settlement Agreement dated October 6, 2002, that forms a basis for  
adjudication of the matters before this Court, IT IS STIPULATED AND ORDERED:

STIPULATION AND ORDER GRANTING  
PERMANENT INJUNCTION  
Case No. C01-1391 WHA



1           1.     This Court has jurisdiction over the subject matter and the Parties. This  
 2 Court retains jurisdiction to resolve any disputes concerning the Settlement Agreement and  
 3 this Stipulation and Order Granting Permanent Injunction. *UP To 3 years only.*  
*W2 Me 10-11-04*

4           2     Semitool owns all of the rights, title, and interest in and to each of the  
 5 following patents:

6                   U.S. Patent No. 5,562,113  
 7                   U.S. Patent No. 5,738,128  
 8                   U.S. Patent No. 5,972,127

9           (These patents are hereinafter referred to as the "Semitool Patents.")

10          3.     The Semitool Patents are valid and enforceable.

11          4.     DMS's Model 300 and Model 310, as presently configured, infringe the  
 12 following claims of the Semitool Patents:

- 13                   a) U.S. Patent No. 5,562,113, claims 1, 4, 11, 12, 17, 18, and 19;  
 14                   b) U.S. Patent No. 5,738,128, claims 1, 3, 8, 9, 11, and 12; and  
 15                   c) U.S. Patent No. 5,972,127, claims 20, 21, 22, 25, 27, 28, 29, 30,  
 16                   31, 33, 36, and 38.

17          5.     DMS is enjoined from: (a) making, using, selling or offering to sell any  
 18 device in the United States that infringes any claim of the Semitool Patents, (b) inducing  
 19 or contributing to another making, using, offering to sell or selling any such device in  
 20 the United States, or (c) importing into the United States any such device or inducing or  
 21 contributing to another importing any such device in the United States. DMS and its  
 22 officers or representatives shall not visit with, place telephone calls to, send documents  
 23 to or in any other way contact anyone located in the United States to solicit the sale of  
 24 any such device to be installed or used in the United States or imported into the United  
 25 States. The acts specified in the immediately preceding sentence do not in any way  
 26 restrict or limit the acts by DMS that may be considered to be violations of this  
 27 permanent injunction.  
 28



6. DMS, its officers, agents, employees and all persons in active concert or participation with DMS shall immediately cease making, using, selling or offering to sell in the United States DMS's Model 300 or Model 310, as presently configured, or any other device that is no more than colorably different from the present configurations of the Model 300 and Model 310. Any further sales, offers for sale, or importation into the United States that are made, induced or contributed to by DMS of the Model 300 or Model 310, as presently configured, in which the device is intended to be installed or used in the United States, would violate this permanent injunction.

7. DMS may maintain, service and repair (without reconstructing) the four Model 300's and one Model 310 already installed at IBM and Conexant for use in the United States. DMS is enjoined from reconstructing any of these five devices.

8. This permanent injunction shall remain in effect so long as at least one of the Semitool patents remains in effect. This permanent injunction will not terminate until all the Semitool Patents have expired.

9. The Court's construction of phrases and terms used in the claims of the Semitool Patents, as specified in the Court's Final Claim Construction Order dated June 17, 2002, shall be used in determining whether DMS is infringing any claims of the Semitool Patents in violation of this permanent injunction. As set forth in the Final Claim Construction Order, the listed terms and phrases are construed as follows:

a). "Drying gas" means an air or other gas with a low-contamination level that is capable of readily absorbing evaporated cleaning liquid from the carriers and removing said vapor(s) from the process chamber as the air or other gas is evacuated therefrom.

b) "Supplying drying gas to the process chamber" means the introduction of "drying gas" into the process chamber. Once inside the process chamber, all that is required is that the "drying gas" has a low-contamination level and is capable of readily absorbing evaporated cleaning liquid from the carriers and removing said vapor(s) from the process chamber as it is evacuated therefrom. Thus, the process chamber may

1 include a device to enhance the absorption/removal capabilities of the "drying gas"  
 2 inside the chamber, *i.e.*, a heater inside the process chamber.

3 c) "Secondary drying gas" is a "drying gas" that is delivered into the  
 4 process chamber in a manner that is separate and apart from the delivery of "primary  
 5 drying gas." There is no need for the "secondary drying gas" to have a source  
 6 independent of the "primary drying gas."

7 d) "Loading carriers through at least one port formed in a sidewall of a  
 8 processing vessel, said carriers being loaded onto at least one carrier support connected  
 9 to a rotor" means the placing of carriers through an opening or passage way within the  
 10 sidewall of a processing vessel. Specifically, the carriers are being loaded onto a carrier  
 11 support that is connected to a rotor. The carriers may be loaded onto the carrier support  
 12 either before or after their passage through the opening or passage way.

13 10. Semitool and DMS shall each be responsible for its own attorney's fees  
 14 and costs incurred in connection with this case.

15 DATED: October 7, 2002

16 PERKINS COIE LLP

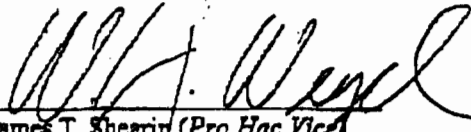
17  
 18 By: Michael D. Broadhus  
 19 Michael D. Broadhus  
 20 Jennifer S. Sim

21 Attorneys for Plaintiff  
 22 Semitool, Inc.

23  
 24 DATED: October 6, 2002

25  
 26 PULLMAN & COMLEY, LLC


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By:   
James T. Shearin (Pro Hac Vice)  
William J. Wenzel (Pro Hac Vice)

Attorneys for Defendant  
Dynamac Micro Systems Semiconductor Equipment  
GmbH

IT IS SO ORDERED.

DATED this 21 day of Oct, 2002.

  
HONORABLE WILLIAM ALSUP  
UNITED STATES DISTRICT JUDGE

The Clerk shall close  
the file for admission  
program. (input the  
re-opening to enforce agreement).  
WHA

STIPULATION AND ORDER GRANTING  
PERMANENT INJUNCTION

WHA011996.1.DOC  
Case No. C01-1391 WHA

**PROOF OF SERVICE**

I Sue E. Daniels, am a citizen of the United States and am an employee in the City and County of San Francisco, State of California. I am over the age of 17 and not a party to the within action. My business address is 180 Townsend Street, 3<sup>rd</sup> Floor, San Francisco, California 94107. On October 8, 2002, I served the following documents:

**STIPULATION AND ORDER GRANTING PERMANENT INJUNCTION**

William J. Wenzel  
FULLMAN & COMLEY, L.L.C.  
850 Main Street, P.O. Box 7006  
Bridgeport, CT 06601-7006

Roger L. Cook  
TOWNSEND AND TOWNSEND AND CREW LLP  
Two Embarcadero Center, 8<sup>th</sup> Floor  
San Francisco, CA 94111

by causing a full, true, and correct copy thereof to be sent by the following indicated method or methods, on the date set forth below:


☒ by sending via overnight courier in a sealed prepaid envelope.

☒ by faxing to the last-known fax number for the attorney's office listed above.

I declare under penalty of perjury under the laws of the State of California that the above is true and correct and that this declaration was executed at San Francisco, California.

DATED: October 8, 2002

  
Sue E. Daniels

  
**SUBMITTING  
COUNSEL DIRECTED  
TO SERVE THIS ORDER  
UPON ALL OTHER  
PARTIES IN THIS  
ACTION**

**Exhibit D**



MICHAEL D. BROADBENT  
206.359.8094  
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Coie

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Seattle, WA 98101-3099  
PHONE: 206.359.8000  
FAX: 206.359.8000  
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May 25, 2004

VIA E-MAIL

William J. Wenzel, Esq.  
Pullman & Comley, L.L.C.  
850 Main Street, P.O. Box 7006  
Bridgeport, CT 06601-7006

Re: Semitool v. DMS, No. C01-1391 WHA (N.D. Calif.)

Dear Bill:

As we discussed this morning, Semitool is quite concerned that DMS is violating the Court's Permanent Injunction by attempting to sell its Model 300 to Infineon in the United States. Attached for reference is a copy of the Permanent Injunction.

According to the information obtained by Semitool, the only modification that DMS has made to the Model 300 since entry of the Permanent Injunction is to supply drying gas through the spray nozzles instead of through the HEPA filter located at the top of the processing chamber.

Even with this modification, the Model 300 would still infringe numerous claims of Semitool's patents, including claims 1, 8, 9, 11 and 12 of U.S. Patent No. 5,738,128 and claims 1, 4, 17, 18 and 19 of U.S. Patent No. 5,562,113. Moreover, any customer who used the Model 300 would infringe several claims of U.S. Patent No. 5,972,127, including claims 20, 21, 22, 28, 29, 30, 31 and 33. DMS would, of course, also be liable for inducing its customer's infringement of that patent.

We appreciate your willingness to forward this letter to DMS and Mr. and Mrs. Moran. We would like to receive as soon as possible a description of the Model 300 offered to Infineon along with an explanation of why DMS believes that system does not infringe Semitool's patents in violation of the Permanent Injunction. As I mentioned, Semitool is prepared to seek a Temporary Restraining Order to stop any violation of the Permanent Injunction by DMS.

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Perkins Coie LLP and Affiliates

[42274-0019/SLD4]480.277]

We look forward to hearing from you or DMS soon.

Sincerely,

A handwritten signature in black ink, appearing to read "Michael D. Broadus". The signature is fluid and cursive, with the first name "Michael" being the most prominent.

Michael D. Broadus

Enclosures

cc: Harry M. Cross, Jr., Esq., Semitool

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(42274-0019/SL04)460.177



## WITTE, WELLER & PARTNER

Patentanwälte

Michael D. Broaddus  
Perkins Cole  
1201 Third Avenue  
Seattle, WA 98101-3009  
USA

May 26, 2004

**VIA TELEFAX**  
(with confirmation copy)

Semitoool, Inc. vs. DMS  
No. C01-1391 WHA (N.D. Calif.)  
Our Docket: 2227V107

Dear Mr. Broaddus,

We are acting for Dynamic Micro Systems Semiconductor Equipment GmbH ("DMS") of Im Wiesengrund 17, D-78315 Radolfzell, Germany in the field of Intellectual Property. Our client has provided me with a copy of your letter of May 25, 2004 to Mr. William J. Wenzel of Pullman & Comley, L.L.C. Please direct all further correspondence in this matter to my attention.

Your letter expresses Semitoool's concern that our client is attempting to sell its Model 300 to Infineon in the United States. Further, your letter states that according to the information obtained by Semitoool, the only modification that DMS has made to the Model 300 since the entry of the Permanent Injunction is to supply drying gas

## WWP

Dr.-Ing. Alexander Wille \*  
Dipl.-Ing.

Dr. rer. nat. Wolfgang Weller  
Dipl.-Chem.

Dr.-Ing. Stefan Gahlert  
Dipl.-Wirtsch.-Ing., M.Sc.

Dr.-Ing. Hajo Otten \*\*  
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Christian Steil  
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Michael Lindner \*  
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Dr. rer. nat. Volker Heuckeroth  
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WITTE, WELLER & PARTNER  
Patentanwälte

2

through the spray nozzles instead of through the HEPA filter located on top of the processing chamber.


Our client's comments are as follows:

1. DMS has not attempted to sell a Model 300 to Infineon in the United States since the entry of the Permanent Injunction.
2. Following the Permanent Injunction, DMS has discontinued to offer for sale or sell its previous Model 300 to anyone in the United States. Instead, DMS has been marketing another cleaning processor in the United States since, and under a distinct other trade name. This processor does not interfere with any of the "Semitool Patents". In particular, it does not comprise means for supplying drying gas through the spray nozzles instead of through the HEPA filter located on top of the processing chamber.

Accordingly, DMS has strictly observed its obligations under the Permanent Injunction and will certainly continue to do so. The information obtained by Semitool and referred to in your letter is, hence incorrect. I am confident that Semitool will come to the same conclusion after having verified its information. Please feel free to get in touch with me should there still be any open questions.

Sincerely

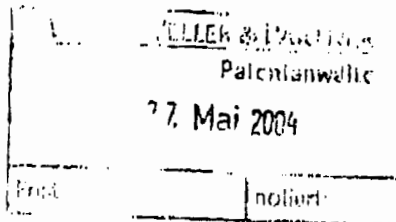
Patentanwalt

  
(Dr. A. Witte)





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May 26, 2004

**VIA E-MAIL AND FACSIMILE**

Dr. Alexander Witte  
Postfach 10 54 62  
70047 Stuttgart  
Germany

**Re: Semitool v. DMS, No. C01-1391 WHA (N.D. Calif.)**

Dear Dr. Witte:

We received your correspondence dated May 26, 2004, and appreciate your prompt response.

In your letter, you state that, following the Permanent Injunction, DMS has been marketing in the United States "another cleaning processor" than the Model 300 under a "distinct other tradename." Based on our review of DMS's web site, it appears that DMS's only cleaning equipment for wafer carriers is the Model 300, which has also been called the "Milestone III" and the "M300" since at least 2001.

Please identify by tradename the other cleaning processor that DMS has been selling in the United States since entry of the Permanent Injunction and generally describe how its operation differs from the Model 300. A copy of DMS's marketing literature for this other cleaning processor would be most helpful. This information will allow Semitool to determine whether DMS is observing its obligations under the Permanent Injunction and avoid the need for any further legal action.

We look forward to hearing from you soon.

Sincerely,

A handwritten signature in cursive script that reads "Michael D. Broaddus".

Michael D. Broaddus

cc: Harry M. Cross, Jr., Esq., Semitool

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Perkins Coie LLP and Affiliates

[43274-0018/SL041470.203]



## WITTE, WELLER & PARTNER

Patentanwälte

Michael D. Broaddus  
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1201 Third Avenue  
Seattle, WA 98101-3009  
USA

June 04, 2004

**VIA TELEFAX**  
(with confirmation copy)

Semitoool Inc. vs. DMS  
No. C01-1391 WHA (N.D. Calif.)  
Our Docket: 2227V107

Dear Mr. Broaddus,

thank you for your telefax of May 26, 2004.

Please excuse the short delay of my response caused by the public holidays in Germany around the Pentecost weekend. My comments to your requests are as follows:

Although I am not aware of any obligation for DMS to disclose such information, in order to show DMS's goodwill approach, please be informed that DMS has marketed the cleaning processor in question within the U.S under the trade name "204 Tornado".

## WWP

Dr.-Ing. Alexander Witte \*  
Dipl.-Ing.

Dr. rer. nat. Wolfgang Weller  
Dipl.-Chem.

Dr.-Ing. Stefan Gahlert  
Dipl.-Wirtsch.-Ing., M.Sc.

Dr.-Ing. Hajo Otten \*\*  
Dipl.-Ing.

Christian Stell  
Dipl.-Ing.

Michael Lindner \*  
Dipl.-Ing.

Dr. rer. nat. Volker Heuckeroth  
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WITTE, WELLER & PARTNER  
Patentanwalte

2

On their website, DMS had generally referred to "M300" in connection with their cleaning systems without differentiating between their classical system and their new system (without drying gas supply). As you may appreciate, nothing in DMS's website dealt with the drying gas issue.

In the meantime, DMS has made an update to their website for differentiating between "M300", a trade name now solely used for their classical system, and their new model "204 Tornado". In compliance with DMS's obligations under the Permanent Injunction an indication was added to the "M300" system, stating that this model is not available within the U.S.

I trust that this update clarifies the situation and fully meets Semitool's concerns.

You have, further, requested that DMS shall submit technical details about their new cleaning system. However, as I have already stated at the outset, I am not aware of any obligation for DMS to submit such information to Semitool. Should such obligation exist, please let me have a copy of the corresponding document. The technical concept behind DMS's new cleaning system involves certain trade secrets which DMS is not prepared to disclose at this time.

Sincerely

Patentanwalt



(Dr. A. Witte)

**Exhibit H**

MICHAEL D. BROADBENT  
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June 4, 2004

**VIA E-MAIL AND FACSIMILE**

Dr. Alexander Witte  
Witte, Weller & Partner  
Postfach 10 54 62  
70047 Stuttgart  
Germany

**Re: Semitool v. DMS, No. C01-1391 WHA (N.D. Calif.)**

Dear Dr. Witte:

Thank you for your letter of today providing some information about DMS's "204 Tornado" system.

As you know, the Permanent Injunction places DMS under the Court's continuing jurisdiction with respect to sales of cleaning systems in the United States that may infringe Semitool's patents. Accordingly, Semitool is entitled to learn information from DMS about such cleaning systems so that Semitool can bring any possible infringement to the Court's attention.

If necessary, Semitool is prepared to issue a subpoena to DMS to obtain sufficient information about the 204 Tornado system so that Semitool can determine whether that system is infringing Semitool's patents. As you may know, the Court entered a Protective Order that would protect any trade secret information that DMS may have regarding its 204 Tornado system.

As noted in my letter of May 26, 2004, Semitool is currently just requesting copies of DMS's marketing literature regarding the 204 Tornado system. Because such documents are presumably distributed to DMS's potential customers, there should be no concerns about potential disclosure of DMS's trade secrets.

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Perkins Cole LLP and Affiliates

[40274-0018/BL041566.890]



We look forward to receiving DMS's marketing literature for the 204 Tornado system at your earliest convenience.

Sincerely,



Michael D. Broaddus

cc: Harry M. Cross, Jr., Esq., Semitool

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[42274-0018/041560.050]



## WITTE, WELLER & PARTNER

Patentanwälte

Michael D. Broaddus  
Perkins Coie  
1201 Third Avenue  
Seattle, WA 98101-3009  
USA

June 7, 2004

**VIA TELEFAX**  
(with Confirmation Copy)

Semitool./ Inc. DMS  
No. C01-1391 WHA (N.D. Calif.)  
Our Docket 2227V107

Dear Mr. Broaddus;

I have discussed your letter of June 4 with our client.

I understand that the Secrecy Order mentioned in your letter means that any trade secret disclosed by DMS by way of this correspondence may not be forwarded to Semitool.

In view of that please find enclosed the requested marketing literature, namely a seven page pamphlet "CFC M204 Tornado" and a one page leaflet "DMS M204 TORNADO Centrifugal Force Cleaner" for your internal information.

## WWP

Dr.-Ing. Alexander Wille \*  
Dipl.-Ing.

Dr. rer. nat. Wolfgang Weller  
Dipl.-Chem.

Dr.-Ing. Stefan Gahlert  
Dipl.-Wirtsch.-Ing., M.Sc.

Dr.-Ing. Hajo Otten \*\*  
Dipl.-Ing.

Christian Steil  
Dipl.-Ing.

Michael Lindner \*  
Dipl.-Ing.

Dr. rer. nat. Volker Heuckeroth  
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WITTE, WELLER & PARTNER

Patentanwälte

2

The seven page pamphlet, unfortunately, has a photograph on its front page that is wrong because it does not show the M204 Tornado machine but a previous M300 Milestone machine instead. This was made erroneously and our client apologizes for this oversight. That pamphlet, however, was handed out to one interested party only within the U.S. as far as our client can determine at this time. Our client has taken the necessary steps to have all copies of this pamphlet collected and destroyed and replaced by copies having the correct photograph as shown on the enclosed one page leaflet.

As you will see, none of these two pieces of literature contains information about the drying process step except that IR drying is used. Therefore, as a further proof of our client's goodwill, our client has authorized me to let you also have a copy of their International Patent Application PCT/EP2004/003764 describing the new concept in detail. This application will be published on or about October 11, 2004. Therefore, please keep all information from this application confidential until the afore-mentioned publication date.

Sincerely,

Patentanwalt



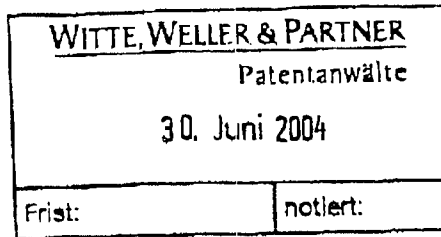
(Dr. A. Witte)

Encl.

Seven page pamphlet „CFC M204 Tornado“  
One page leaflet „DMS M204 TORNADO Centrifugal Force Cleaner“  
International Patent Application  
(all to follow together with the confirmation copy of this letter)







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June 29, 2004

**VIA E-MAIL AND FACSIMILE**

Dr. Alexander Witte  
Witte, Weller & Partner  
Postfach 10 54 62  
70047 Stuttgart  
Germany

Re: Semitool v. DMS, No. C01-1391 WHA (N.D. Calif.)

Dear Dr. Witte:

We have obtained an English translation of the documents included with your June 7 letter describing DMS's M204 Tornado system. Based on our review of those documents, we believe that the Tornado system infringes at least the following claims of Semitool's patents: U.S. Patent No. 5,562,113 (claims 39 and 56) and U.S. Patent No. 5,972,127 (claims 20, 21, 22, 25 and 26).

DMS's M204 Tornado system is merely a slight redesign of DMS's Model 300 that the Court has already determined infringes Semitool's patents. In particular, the M204 Tornado system still supplies drying gas to the processing chamber as specified by the claims of Semitool's patents. In addition, the M204 Tornado system contains all the other elements of the specified claims of Semitool's patents and therefore infringes those patents. We will provide more detail concerning DMS's infringement in a separate letter that includes information that you have indicated is confidential to DMS.

As you know, the Permanent Injunction prohibits DMS from "making, using, selling or offering to sell any device in the United States that infringes any claim of the Semitool Patents." See Permanent Injunction, ¶ 5. Accordingly, Semitool requests that DMS immediately cease its efforts to sell the M204 Tornado system in the United States, including withdrawing any offers that DMS has made to sell that system to a customer in the United States.

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[42274-0018/SL041800.142]

Semitool is prepared to file a motion in the United States District Court for the Northern District of California to enforce the Permanent Injunction and obtain a Court order prohibiting DMS from selling the M204 Tornado system in the United States. Semitool hopes, however, that DMS will voluntarily stop selling the M204 Tornado system in the United States and thereby avoid any further Court action. Please note that, under the Settlement Agreement, if Semitool is required to obtain a Court order, DMS will have to pay Semitool's attorneys' fees and costs. *See* Settlement Agreement, § 12.

We look forward to receiving DMS's prompt response.

Sincerely,



Michael D. Broaddus

cc: Harry M. Cross, Jr., Esq., Semitool